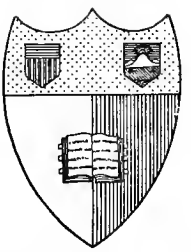
STEAM CHARTS

AND

SPECIAL TABLES FOR TURBINE CALCULATIONS



STEAM CHARTS

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AND

SPECIAL TABLES FOR TURBINE CALCULATIONS

BY

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SPECIAL EDITION

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PREFACE

THIS little book is intended to be of assistance to engineers and students when making calculations involving wet or superheated steam. The chief aim of the author has been to prepare a set of steam charts which shall be accurate and comprehensive, and at the same time convenient to handle, and easy to read. An attempt has also been made to give, concisely, the corrections to be applied to the readings of mercury columns, and to prepare a table of velocities, which it is hoped may prove useful.

In order to illustrate some of the uses of the charts and tables, and also to aid those who may desire it, a number of problems, with their solutions, have been added. To make these of more assistance, they have been indexed. For the further aid of those who may desire a brief review of the thermodynamics of steam, and in order to make clear the meaning of all terms used, the few pages of Fundamental Principles were written.

For the main chart, total heat and specific volume were chosen as coordinates because of the fact that upon these two values could be plotted lines of constant pressure, entropy and quality (or superheat), so that each pair of the five sets of lines will make clear intersections. The total heat entropy chart does not permit this. To complete the set of values ordinarily needed, the curve was added, showing the heat of the liquid and temperature of vaporization. The supplementary chart, Plate 8, enables one to read the external work, and therefore obtain easily the intrinsic heat. The index chart for Plates 1 to 6 was made to give a general idea of the relative position and shape of each set of lines, to show quickly the limiting values for each of the six sections, and to assist in determining the particular plate needed.

The range of pressures, qualities, and superheats is intended to be more than sufficient for present practice. For the wet region the inch of mercury was used as the main unit to represent pressures

less than one pound absolute, as it is believed that this is the more convenient one for practical work. Special endeavor has been made to prevent confusion of these two units by using broken lines to represent pressures in inches of mercury, and by putting the proper units with each numeral representing pressure in this region.

The book form of chart was chosen because the author believes that it will be of greater convenience and easier to read than a large folded chart made to the same scales. By making the plates small the eye has to travel only a short distance to read the scales, and this may also be done without requiring any desk space whatever. The book form also has the advantages of better protecting the chart, permitting a quicker reference, and wasting less space in the corners, than does the same chart when in the form of a large folded sheet.

To Prof. Lionel S. Marks and to Dr. Harvey N. Davis, and to their publishers, Longmans, Green & Co., the author desires to express his thanks for permission to use their steam tables in preparing these charts. He also wishes to acknowledge his indebtedness to Prof. Albert W. Smith, Director of Sibley College, and to Prof. William N. Barnard, for their many helpful criticisms; and to Mr. C. H. Berry and Mr. E. T. Jones, instructors in Sibley College, for their able assistance in preparing the charts and oroblems.

F. O. E.

ITHACA, New York, August, 1914.

PREFACE TO THE SPECIAL EDITION

This special form of the author's "Steam Charts" is the result of an attempt to comply with the suggestions of a number of prominent engineers who are engaged in steam turbine design. These suggestions involve the use of a flexible binding and the elimination of the solutions of problems and all explanatory matter, in order to increase the convenience of the book when used by those thoroughly conversant with its applications. Pages from 1 to 23 and from 44 to 91 have therefore been omitted in this edition.

The table of velocities has been supplemented by another table giving the velocities for *each tenth* of a heat unit up to 80 B.t.u. This table was not carried to higher values because Table IV already gives the velocities for each heat unit under 600 B.t.u., and it is evident that above about 80 B.t.u. the increment of velocity for each heat unit is so small that interpolation for tenths is very easily made. A table of the squares of numbers from 200 to 2000 has also been added. The author's experience in turbine calculations leads him to believe that these additional tables are needed, and he therefore hopes that their uses may justify their publication.

F. O. E.

ITHACA, N. Y., March, 1917.

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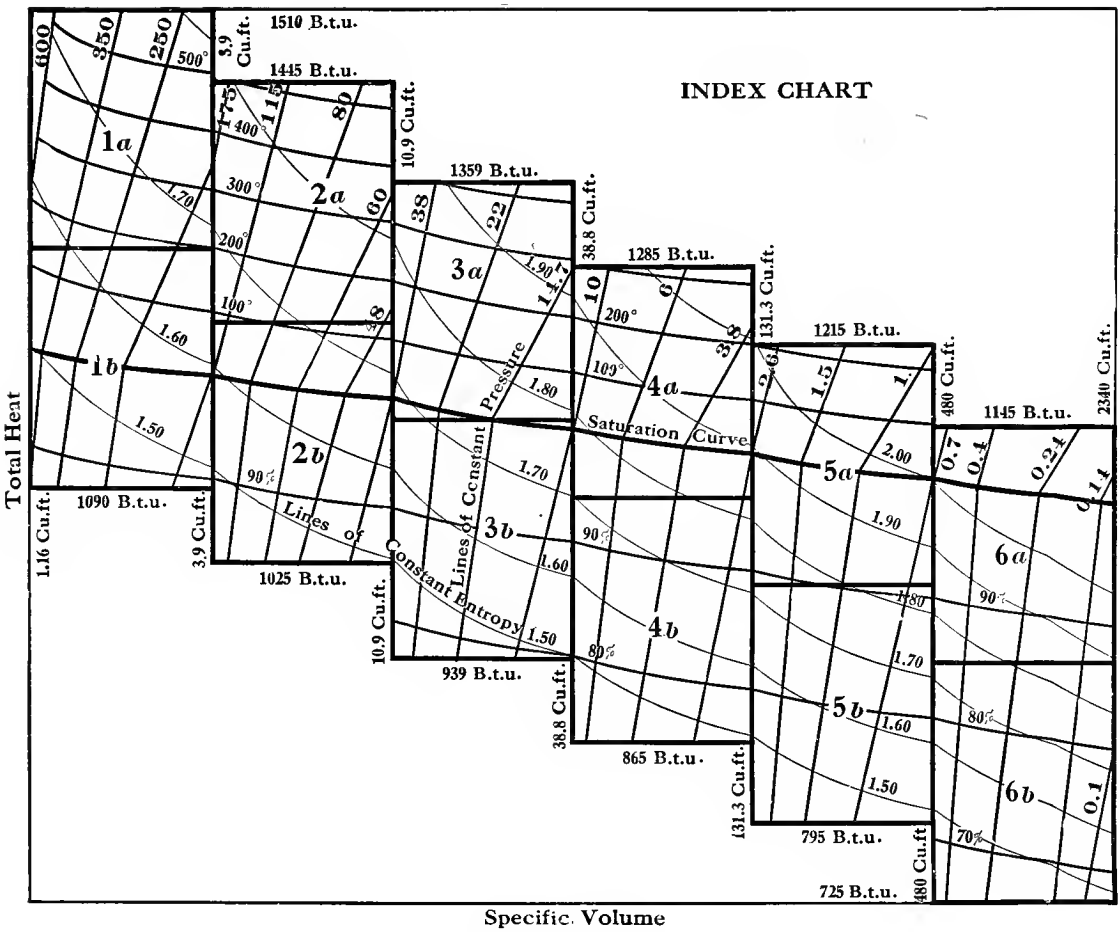
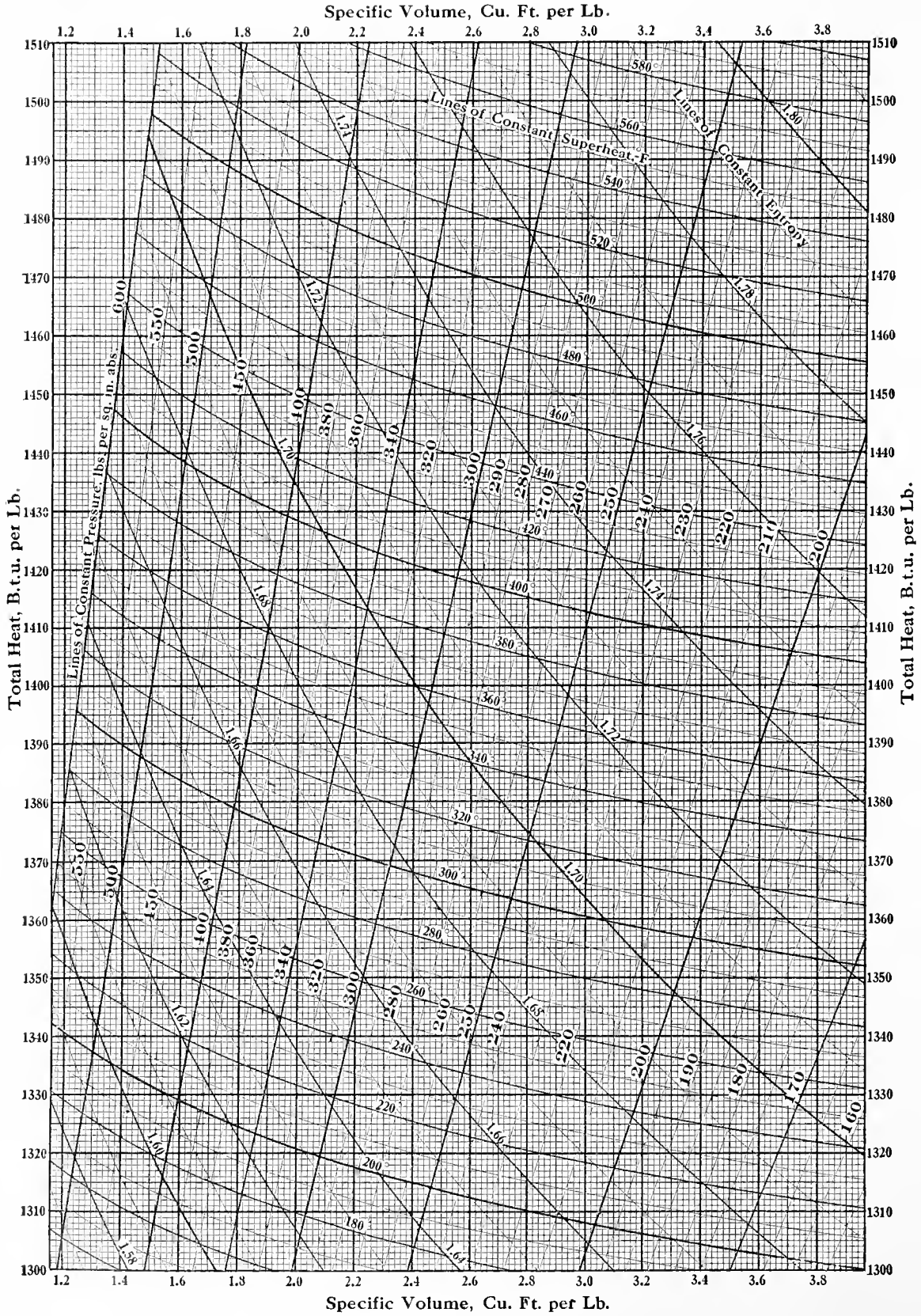
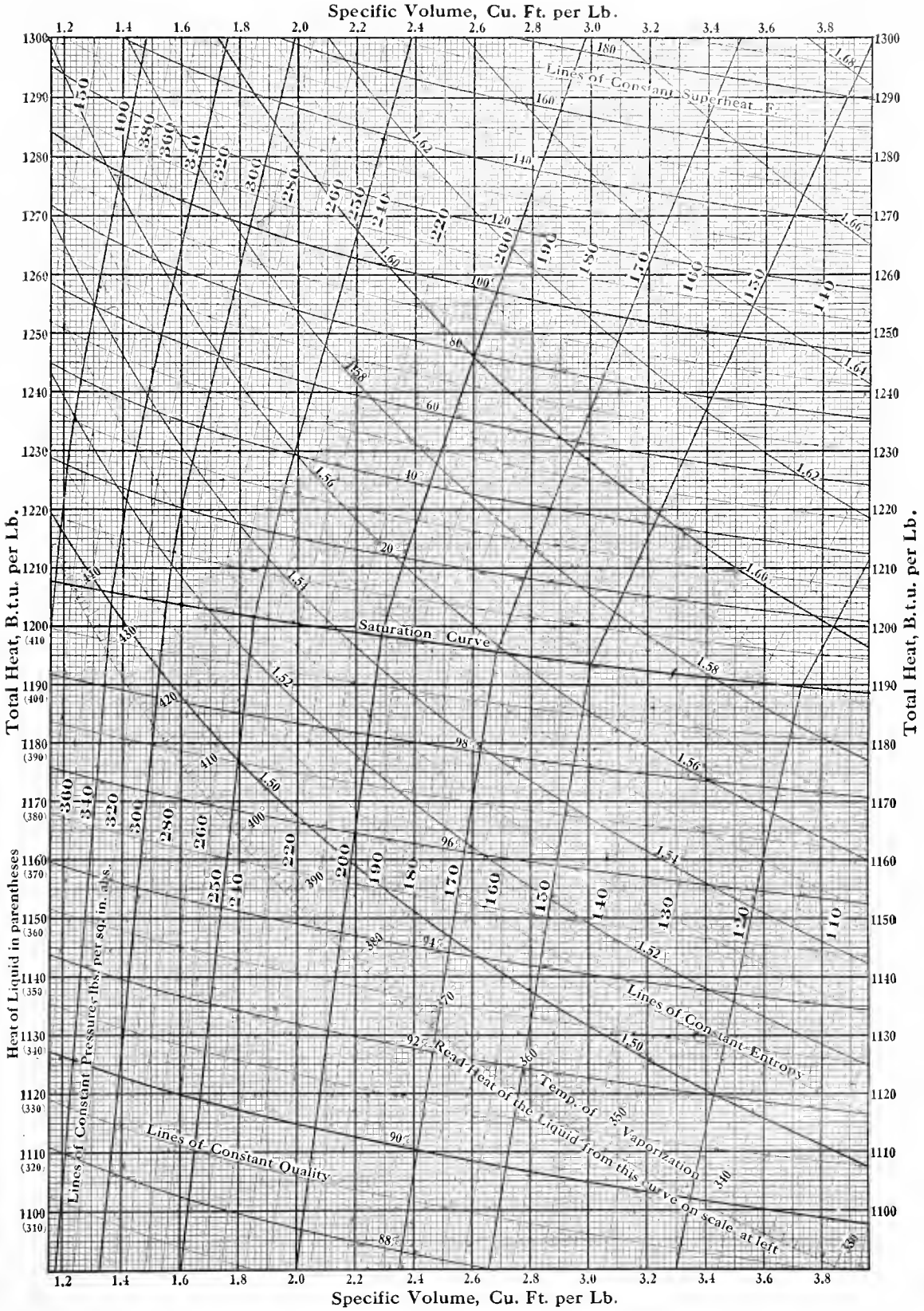
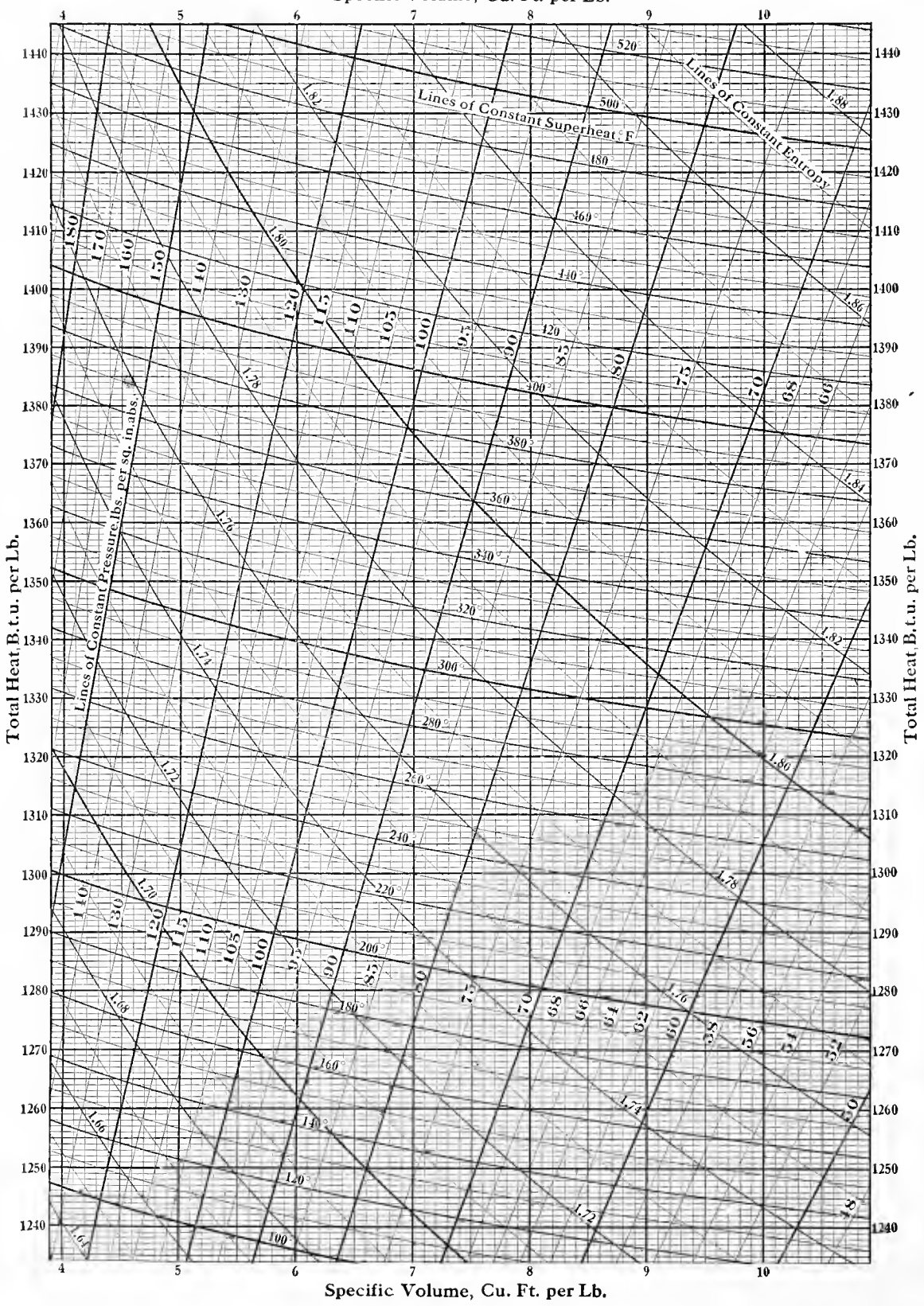
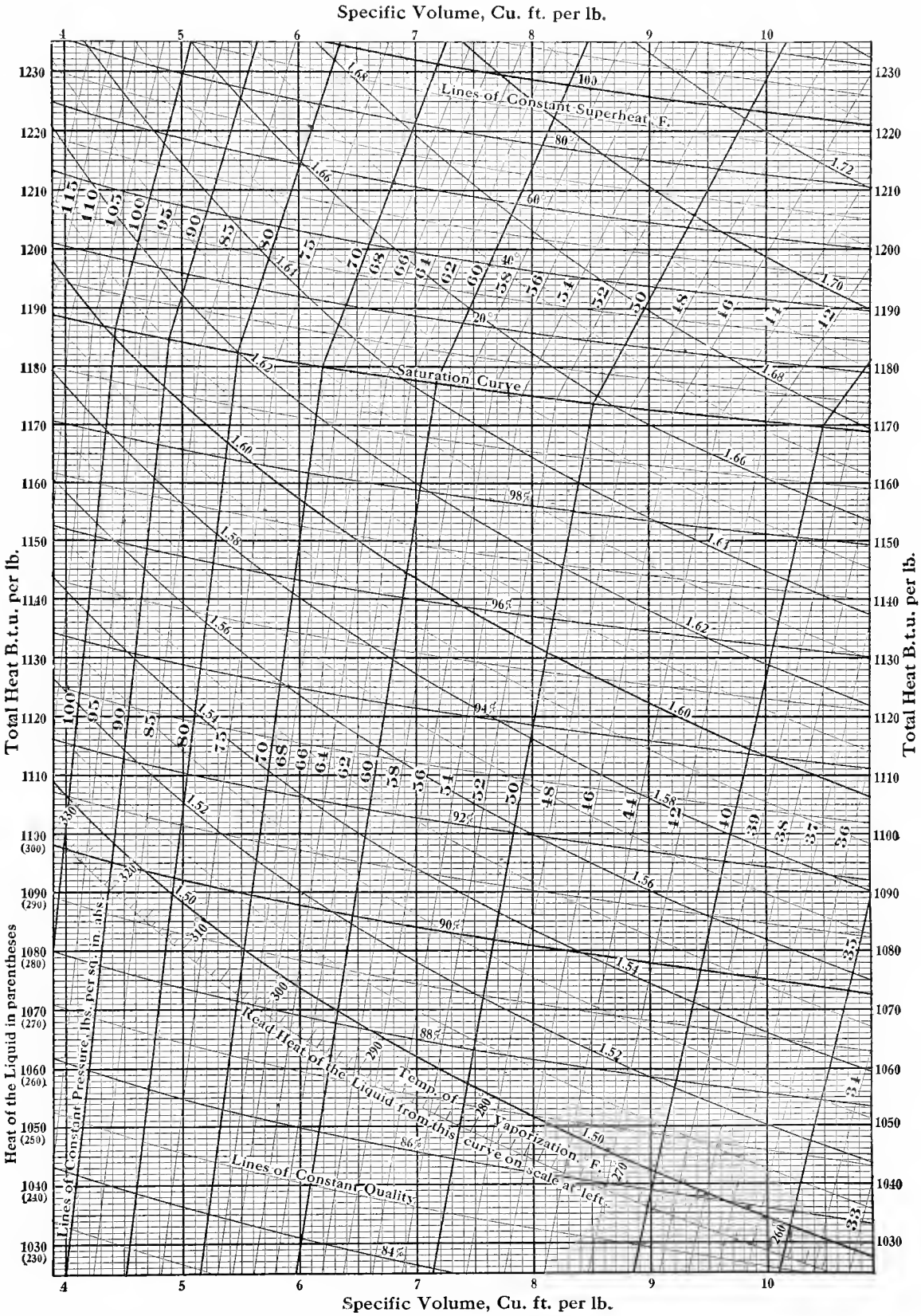
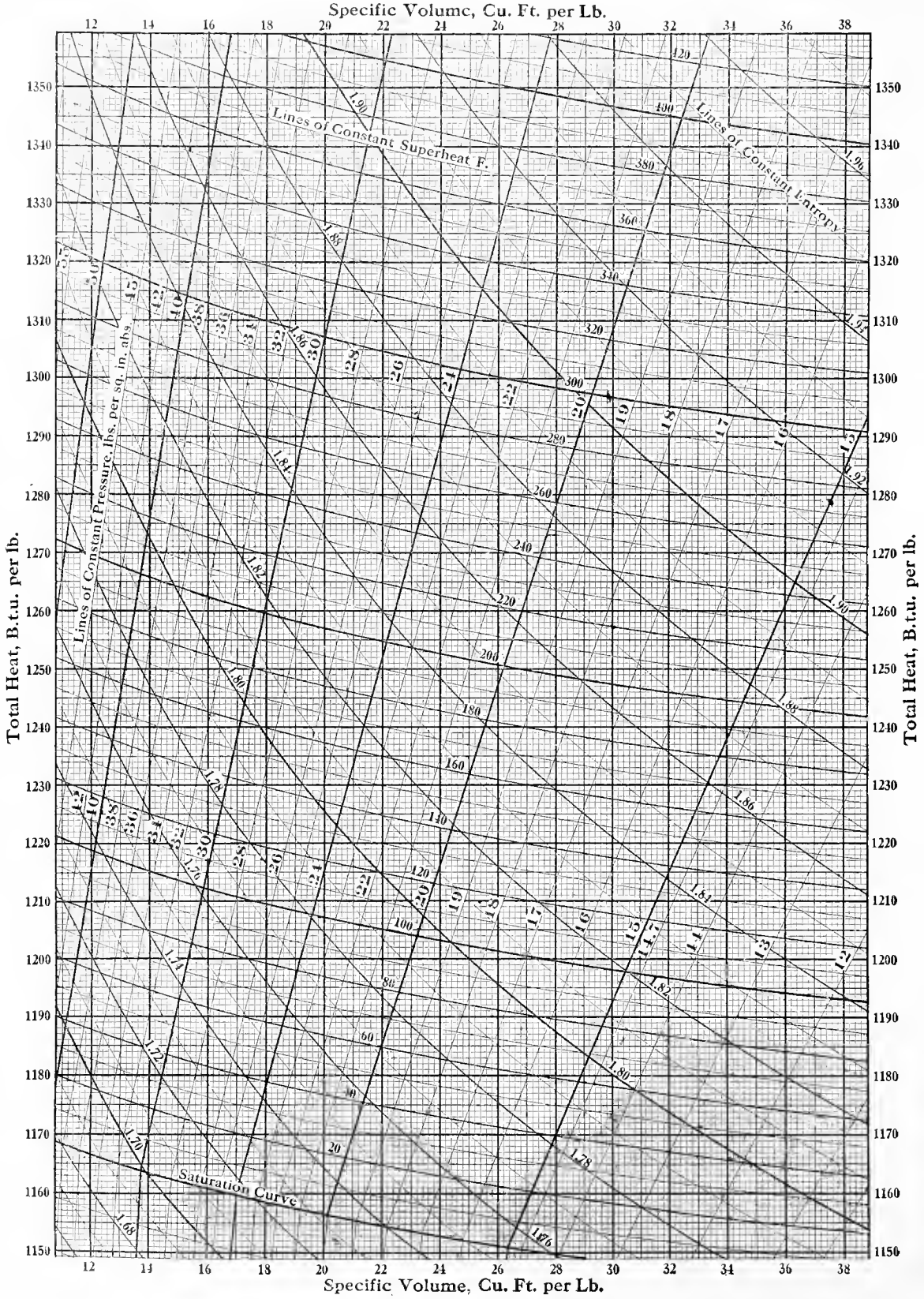

INDEX CHART
Total Heat
Specific Volume
Saturation Curve
Lines of Constant Pressure
Lines of Constant Entropy
1a
1b
2a
2b
3a
3b
4a
4b
5a
5b
6a
6b
600
350
250
500°
400°
300°
200°
100°
1.70
1.60
1.50
1.90
1.80
1.70
1.60
1.50
90%
80%
70%
1510 B.t.u.
1445 B.t.u.
1359 B.t.u.
1285 B.t.u.
1215 B.t.u.
1145 B.t.u.
1090 B.t.u.
1025 B.t.u.
939 B.t.u.
865 B.t.u.
795 B.t.u.
725 B.t.u.
1.16 Cu.ft.
3.9 Cu.ft.
10.9 Cu.ft.
38.8 Cu.ft.
131.3 Cu.ft.
480 Cu.ft.
2340 Cu.ft.
175
150
125
80
60
38
22
10
6
3.6
2.6
1.5
1
0.7
0.4
0.24
0.14
0.1
2.00

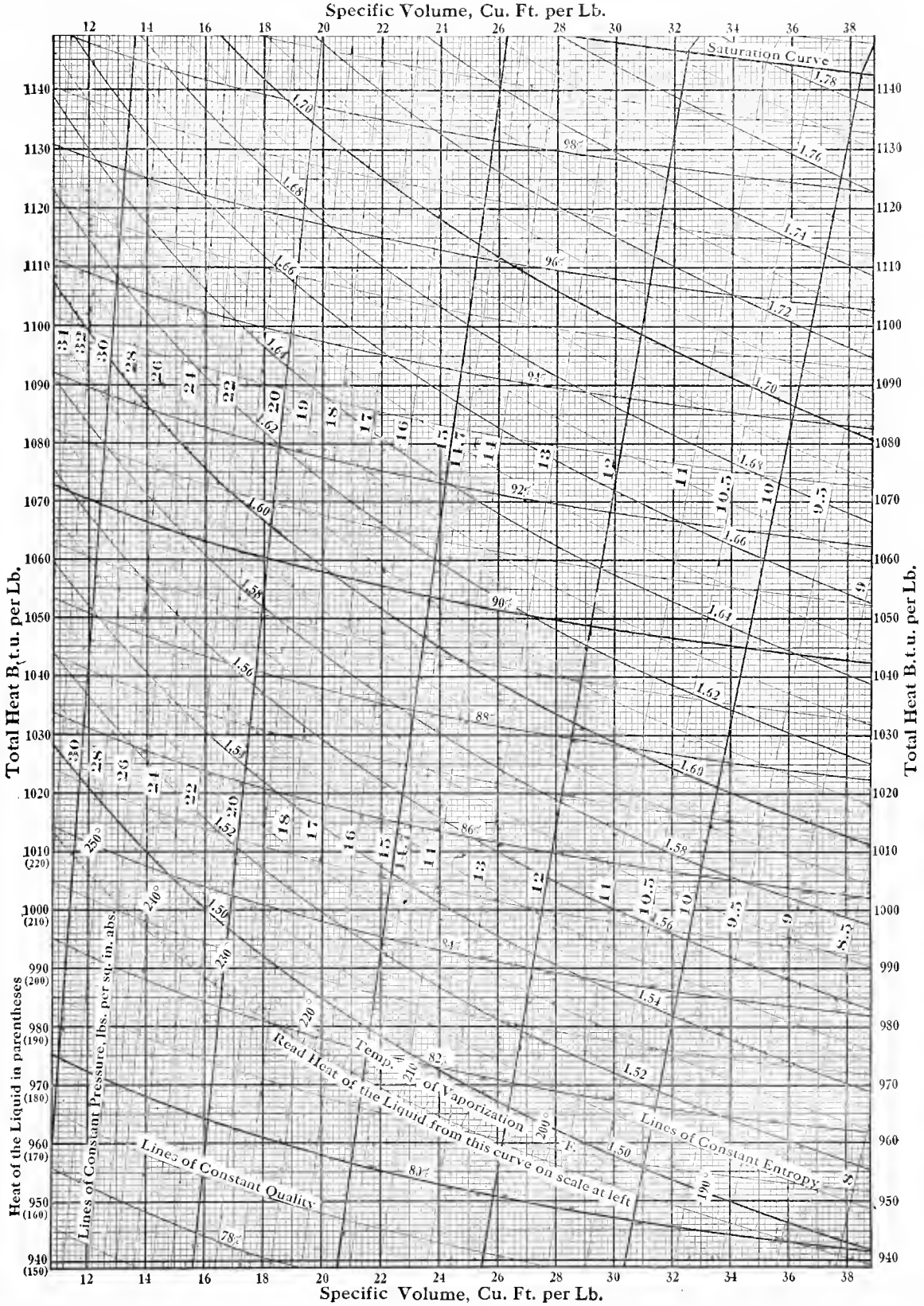

Specific Volume, Cu. Ft. per Lb.
Total Heat, B.t.u. per Lb.
Lines of Constant Pressure, lbs. per sq. in. abs.
Lines of Constant Superheat, °F.
Lines of Constant Entropy
1.2 1.4 1.6 1.8 2.0 2.2 2.4 2.6 2.8 3.0 3.2 3.4 3.6 3.8
1510 1500 1490 1480 1470 1460 1450 1440 1430 1420 1410 1400 1390 1380 1370 1360 1350 1340 1330 1320 1310 1300
600 550 500 450 400 380 360 340 320 300 290 280 270 260 250 240 230 220 210 200
580° 560° 540° 520° 500° 480° 460° 440° 420° 400° 380° 360° 340° 320° 300° 280° 260° 240° 220° 200° 180°
1.80 1.78 1.76 1.74 1.72 1.70 1.68 1.66 1.64 1.62 1.60 1.58
190 180 170 160

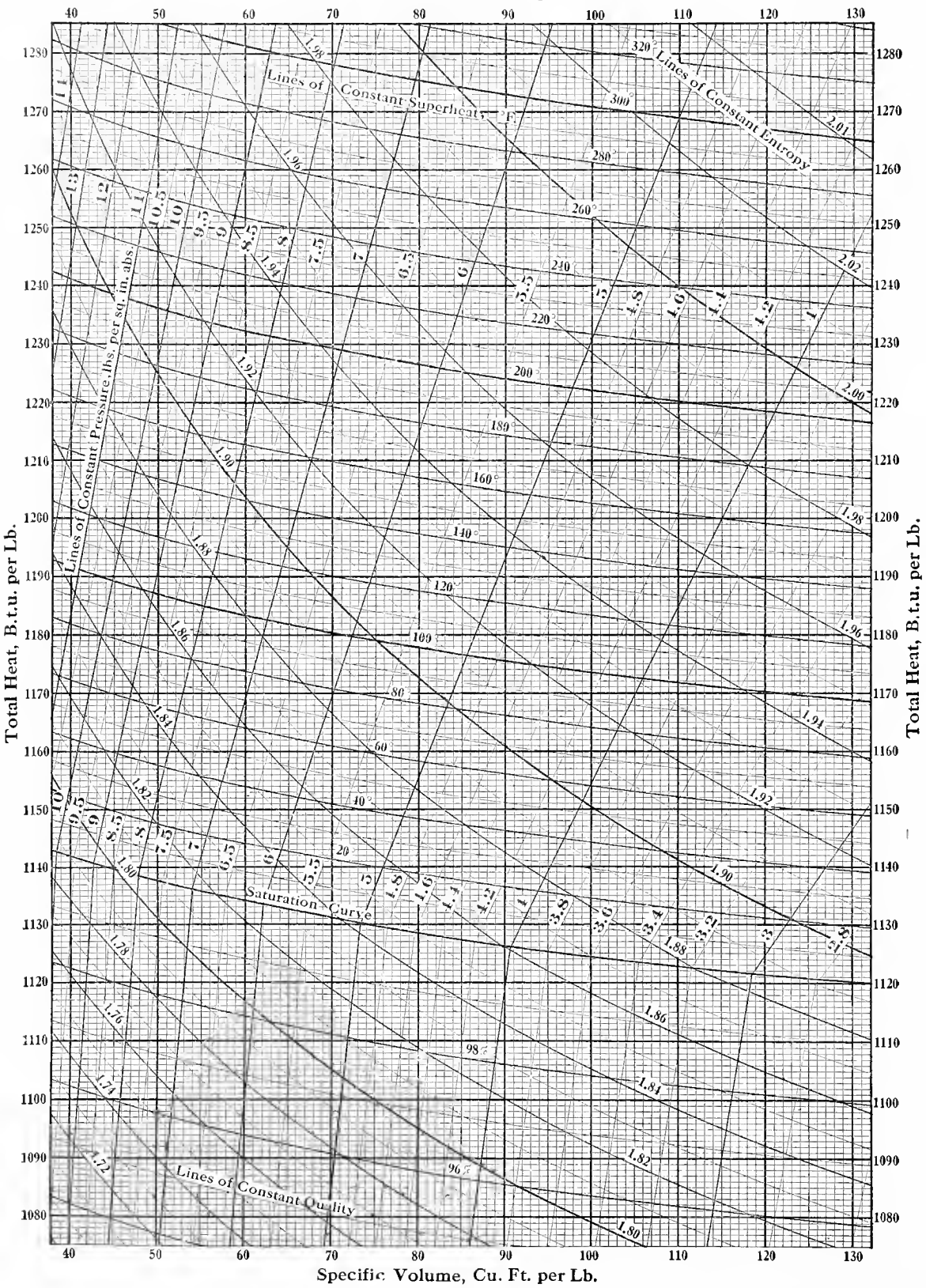

Specific Volume, Cu. Ft. per Lb.
Total Heat, B.t.u. per Lb.
Heat of Liquid in parentheses
Lines of Constant Pressure-lbs. per sq. in. abs.
Lines of Constant Quality
Saturation Curve
Lines of Constant Superheat, F.
Lines of Constant Entropy
Real Heat of the Liquid from this curve on scale at left
Temp. of Vaporization

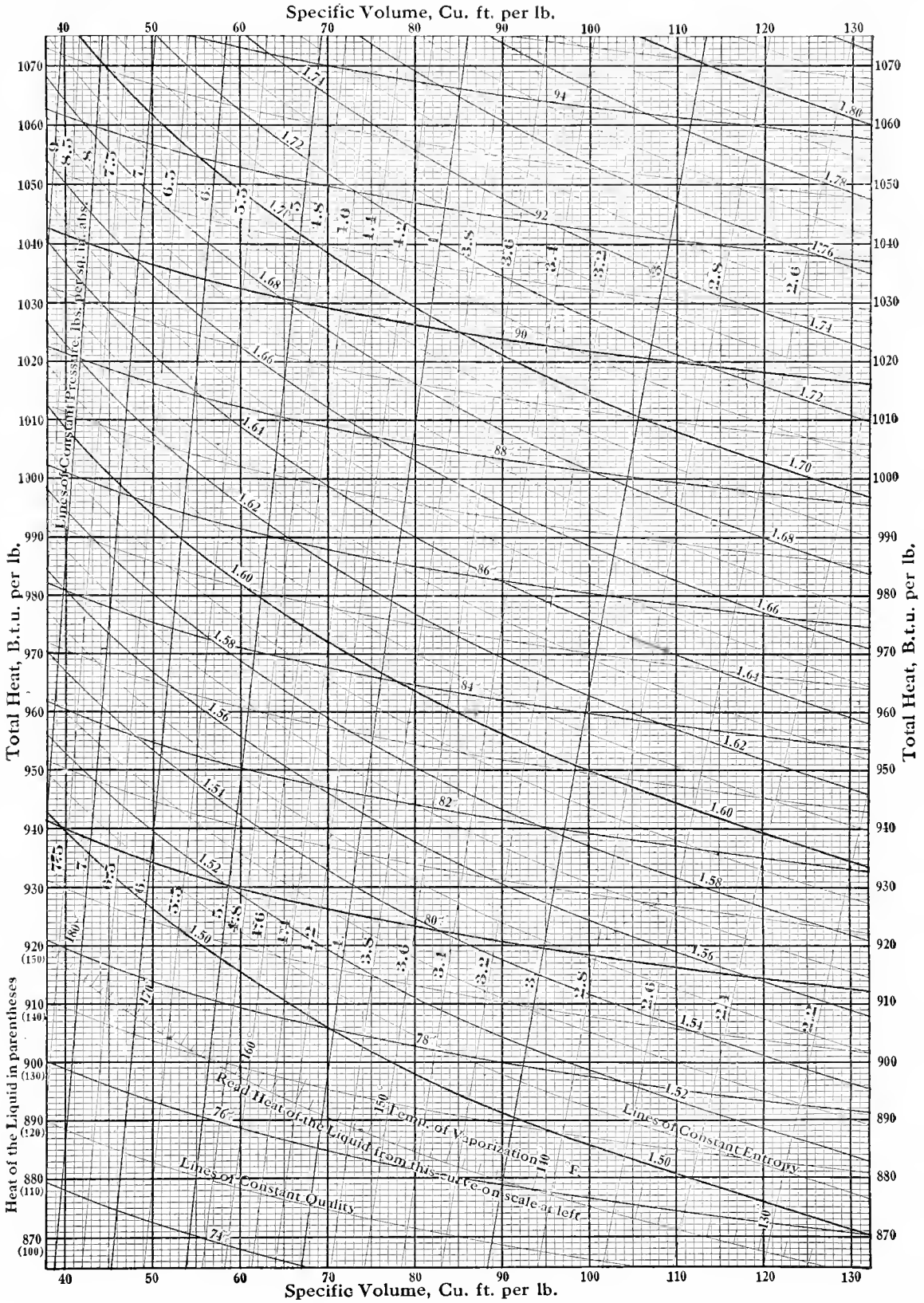

Specific Volume, Cu. Ft. per Lb.
Total Heat, B.t.u. per Lb.
Lines of Constant Pressure, lbs. per sq. in. abs.
Lines of Constant Superheat, F
Lines of Constant Entropy
Specific Volume, Cu. Ft. per Lb.
Total Heat, B.t.u. per Lb.

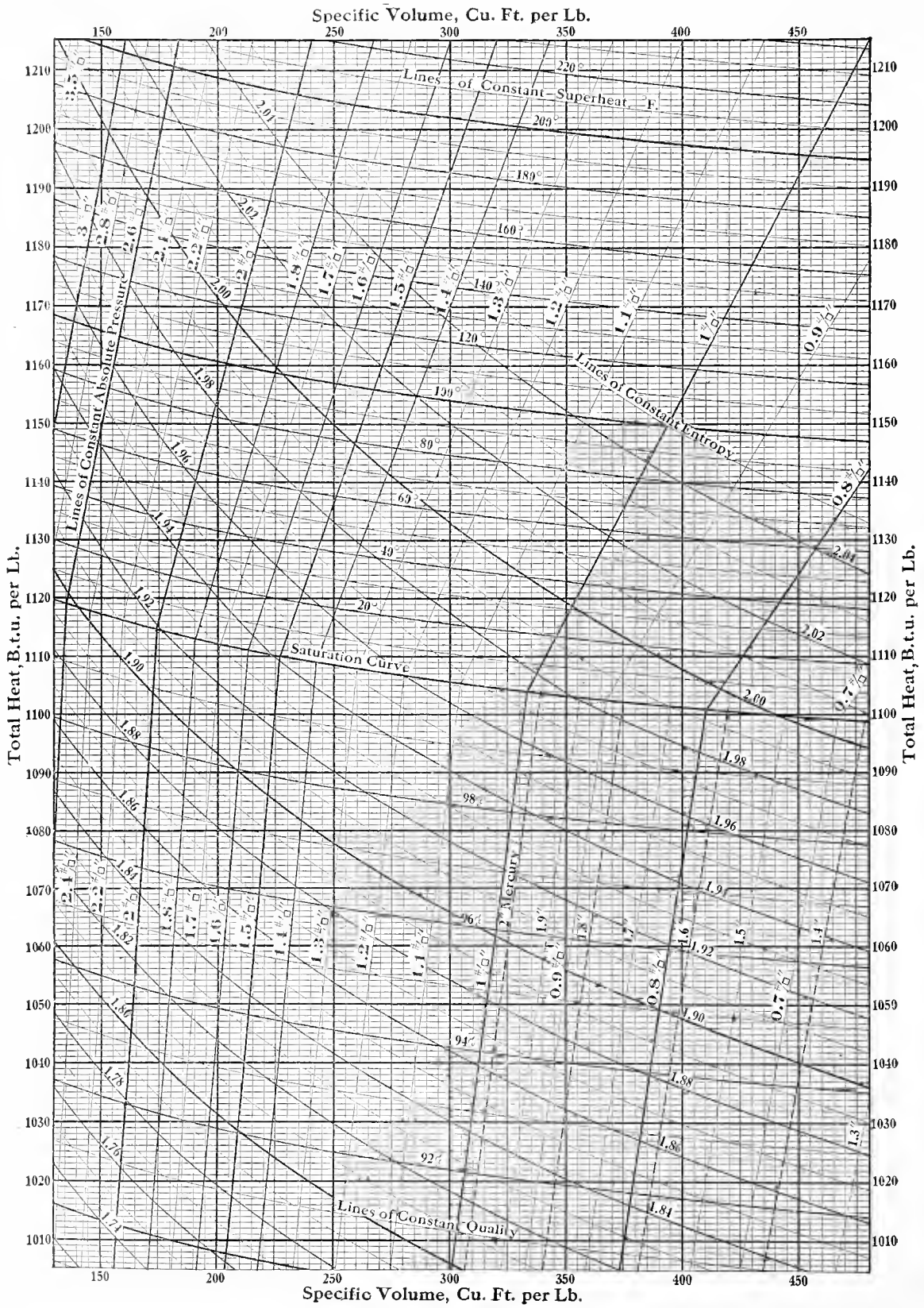

Specific Volume, Cu. ft. per lb.
Total Heat B.t.u. per lb.
Heat of the Liquid in parentheses
Lines of Constant Pressure, lbs. per sq. in. abs.
Lines of Constant Superheat, F.
Saturation Curve
Lines of Constant Quality
Read Heat of the Liquid from this curve on scale at left
Temp. of Vaporization, F.

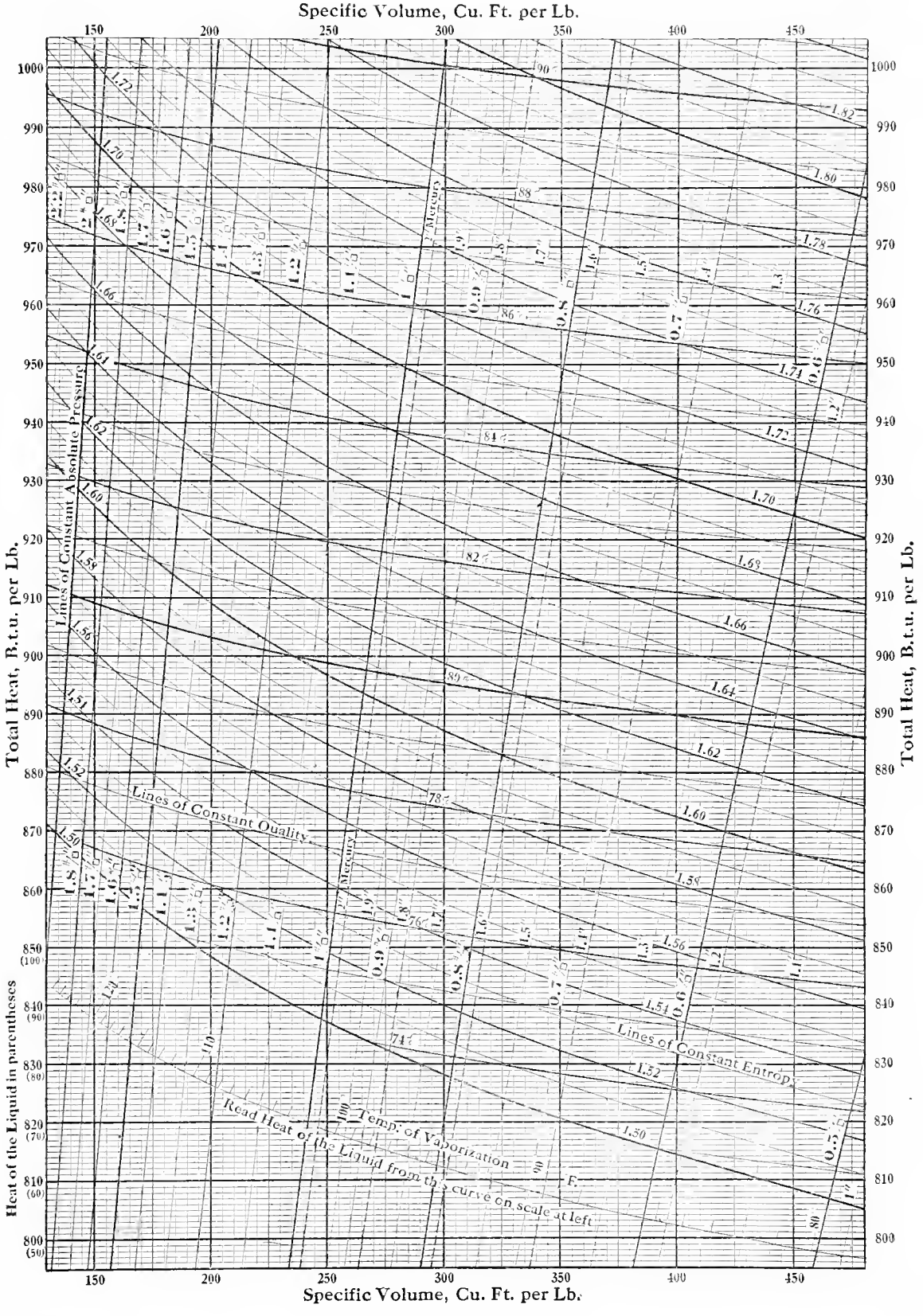

Specific Volume, Cu. Ft. per Lb.
Total Heat, B.t.u. per lb.
Lines of Constant Superheat F.
Lines of Constant Entropy
Lines of Constant Pressure, lbs. per sq. in. abs.
Saturation Curve
Specific Volume, Cu. Ft. per Lb.
Total Heat, B.t.u. per lb.

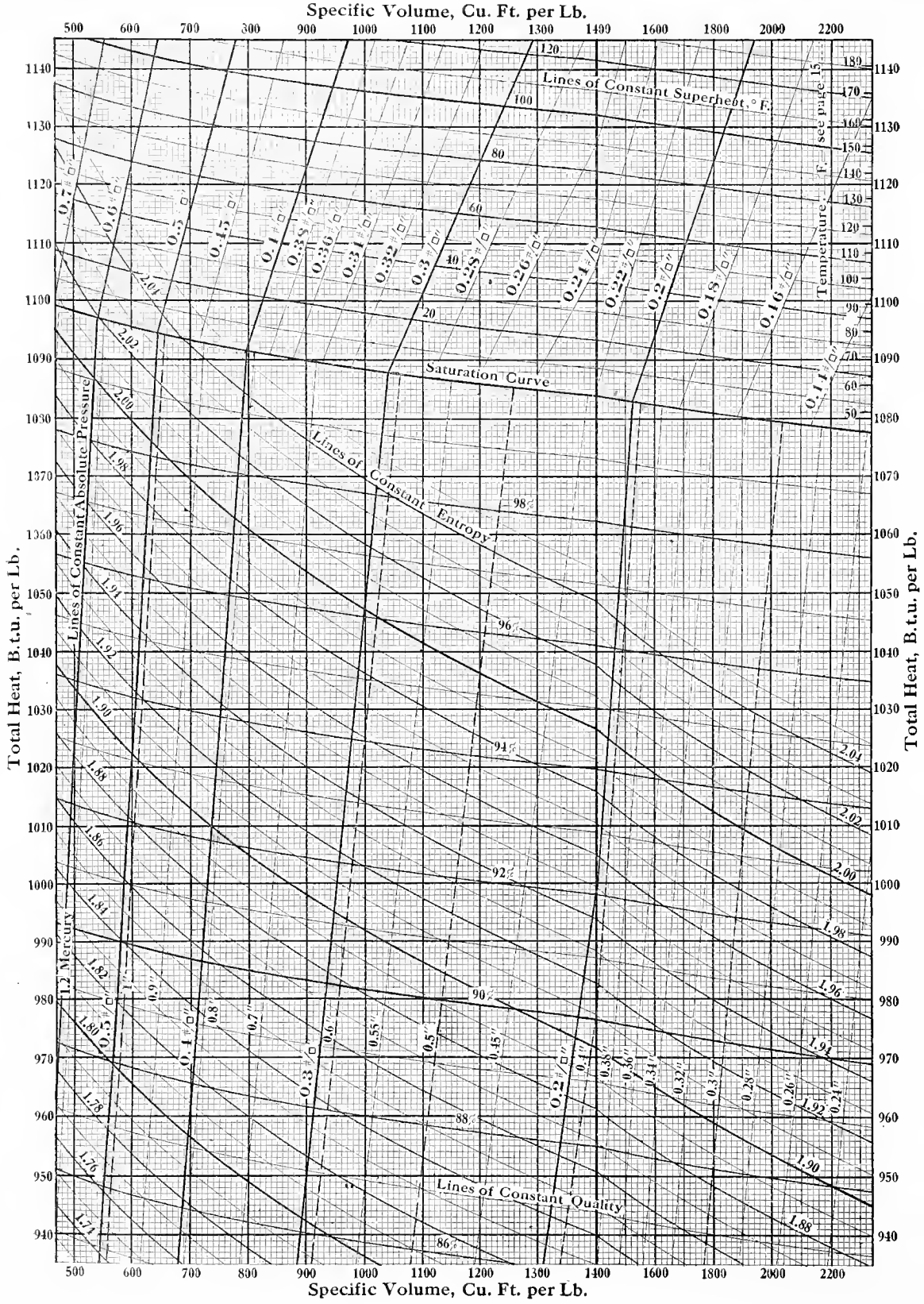

Specific Volume, Cu. Ft. per Lb.
Saturation Curve
Total Heat B.t.u. per Lb.
Heat of the Liquid in parentheses
Lines of Constant Pressure, lbs. per sq. in. abs.
Lines of Constant Quality
Lines of Constant Entropy
Temp. of Vaporization
Read Heat of the Liquid from this curve on scale at left
Specific Volume, Cu. Ft. per Lb.

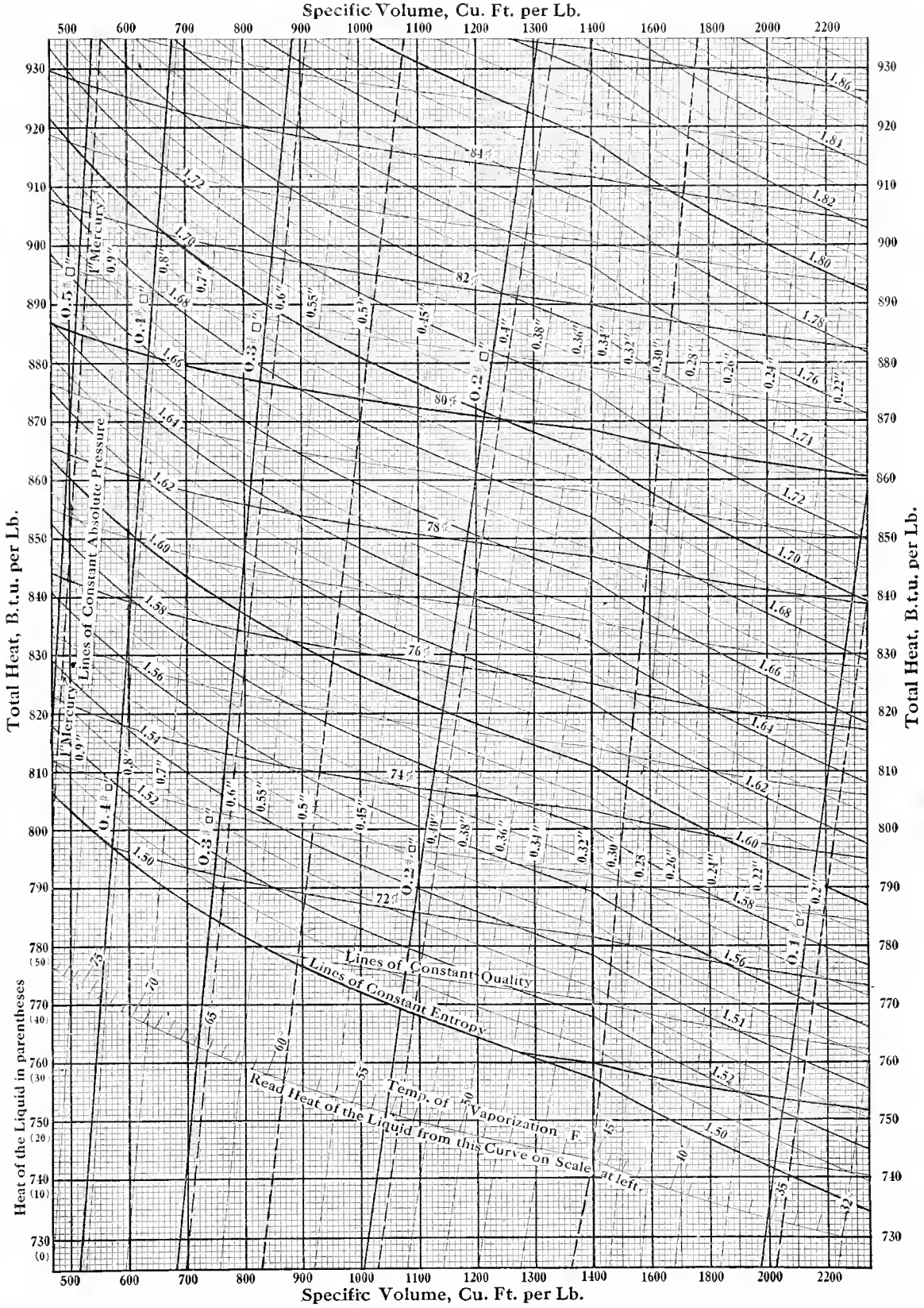

Specific Volume, Cu. Ft. per Lb.
Total Heat, B.t.u. per Lb.
Lines of Constant Superheat, °F.
Lines of Constant Entropy
Lines of Constant Pressure, lbs. per sq. in. abs.
Saturation Curve
Lines of Constant Quality

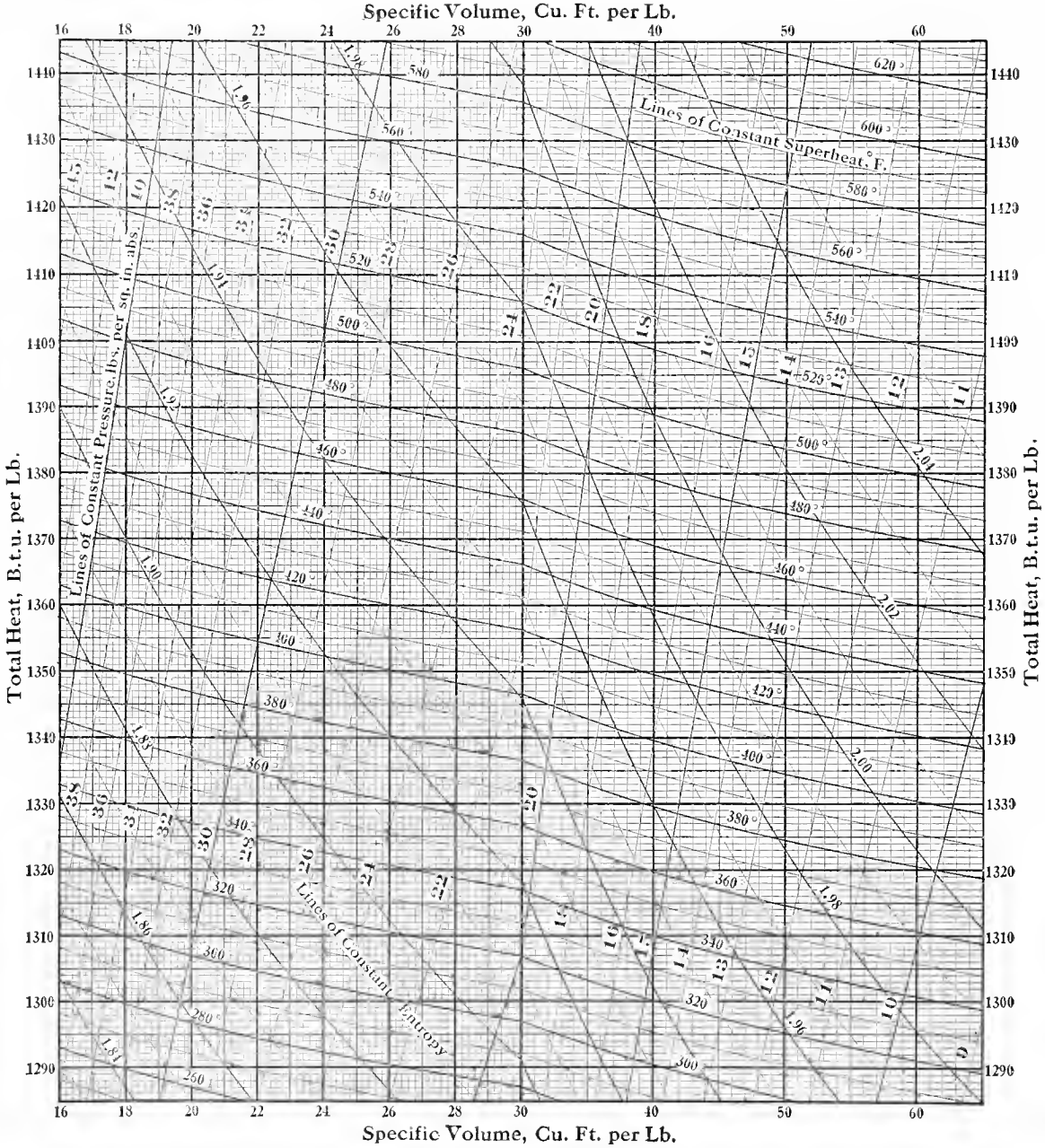

Specific Volume, Cu. ft. per lb.
Total Heat, B.t.u. per lb.
Lines of Constant Pressure, lbs. per sq. in. abs.
Heat of the Liquid in parentheses
Read Heat of the Liquid from this curve on scale at left
Temp. of Vaporization in °F.
Lines of Constant Entropy
Lines of Constant Quality


Specific Volume, Cu. Ft. per Lb.
Total Heat, B.t.u. per Lb.
Lines of Constant Superheat, F.
Lines of Constant Absolute Pressure
Lines of Constant Entropy
Saturation Curve
Lines of Constant Quality
2" Mercury


Specific Volume, Cu. Ft. per Lb.
Total Heat, B.t.u. per Lb.
Heat of the Liquid in parentheses
Lines of Constant Absolute Pressure
Lines of Constant Quality
Lines of Constant Entropy
Read Heat of the Liquid from this curve on scale at left
Temp. of Vaporization
Mercury
F.

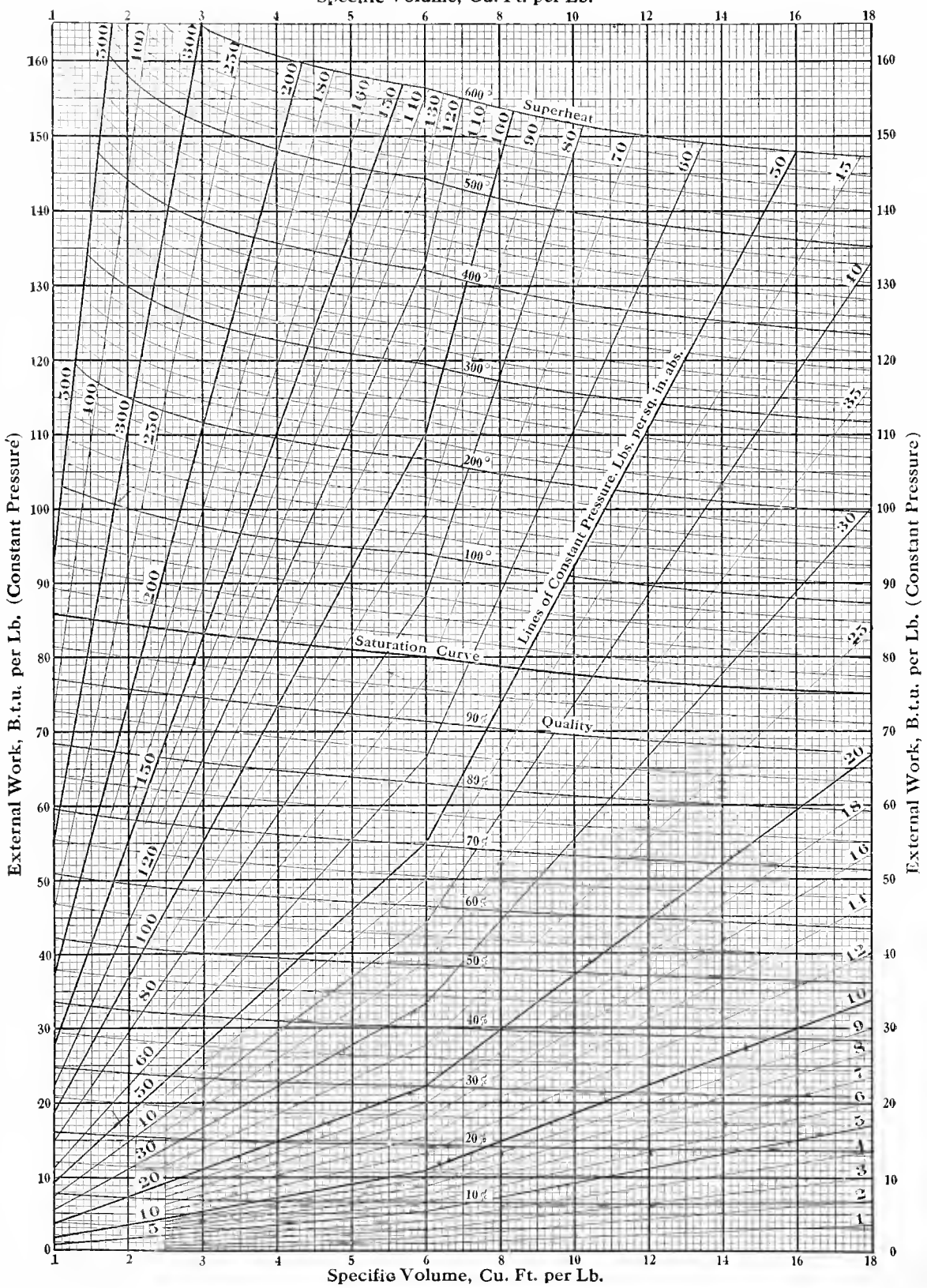

Specific Volume, Cu. Ft. per Lb.
Total Heat, B.t.u. per Lb.
Lines of Constant Superheat, ° F.
Temperature, F., see page 15
Saturation Curve
Lines of Constant Entropy
Lines of Constant Absolute Pressure
Lines of Constant Quality
12 Mercury


Specific Volume, Cu. Ft. per Lb.
500 600 700 800 900 1000 1100 1200 1300 1400 1600 1800 2000 2200
Total Heat, B.t.u. per Lb.
930 920 910 900 890 880 870 860 850 840 830 820 810 800 790 780 770 760 750 740 730
Heat of the Liquid in parentheses
(50) (40) (30) (20) (10) (0)
Lines of Constant Absolute Pressure
1" Mercury
0.9" 0.8" 0.7" 0.6" 0.55" 0.5" 0.45" 0.4" 0.38" 0.36" 0.34" 0.32" 0.30" 0.28" 0.26" 0.24" 0.22"
0.5 # 0.4 # 0.33 # 0.2 # 0.1 #
1.86 1.84 1.82 1.80 1.78 1.76 1.74 1.72 1.70 1.68 1.66 1.64 1.62 1.60 1.58 1.56 1.54 1.52 1.50
84 82 80 78 76 74 72
Lines of Constant Quality
Lines of Constant Entropy
Temp. of Vaporization F.
75 70 65 60 55 50 45 40 35 32
Read Heat of the Liquid from this Curve on Scale at left.



THIS PLATE IS TO SUPPLEMENT PLATES 3A AND 4A FOR THOSE EXCEPTIONAL CASES IN WHICH EXTREMELY HIGH SUPERHEAT IS USED FOR COMPARATIVELY LOW PRESSURES.

THE TWO FOLLOWING PLATES GIVE THE EXTERNAL WORK DONE DURING THE CONSTANT PRESSURE FORMATION OF STEAM FROM WATER AT 32° F.


Specific Volume, Cu. Ft. per Lb.
External Work, B.t.u. per Lb. (Constant Pressure)
Superheat
Saturation Curve
Quality
Lines of Constant Pressure, Lbs. per sq. in. abs.

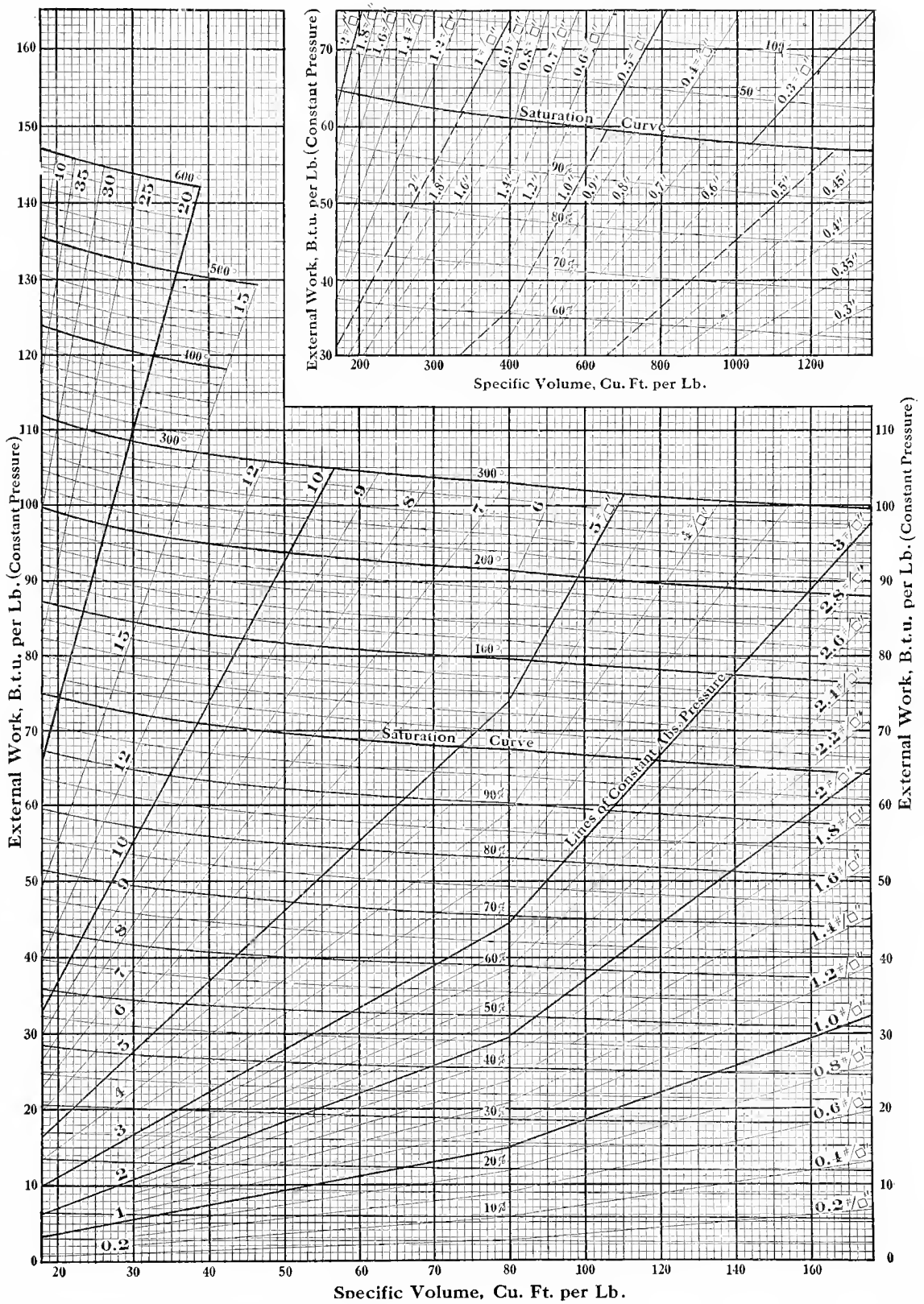

External Work, B.t.u. per Lb. (Constant Pressure)
Specific Volume, Cu. Ft. per Lb.
Saturation Curve
Lines of Constant Lbs. Pressure
External Work, B.t.u. per Lb. (Constant Pressure)
Specific Volume, Cu. Ft. per Lb.
Saturation Curve

Plate 9A

Showing correction of Mercury Column due to Temperature, when scale is correct at the observed temperature

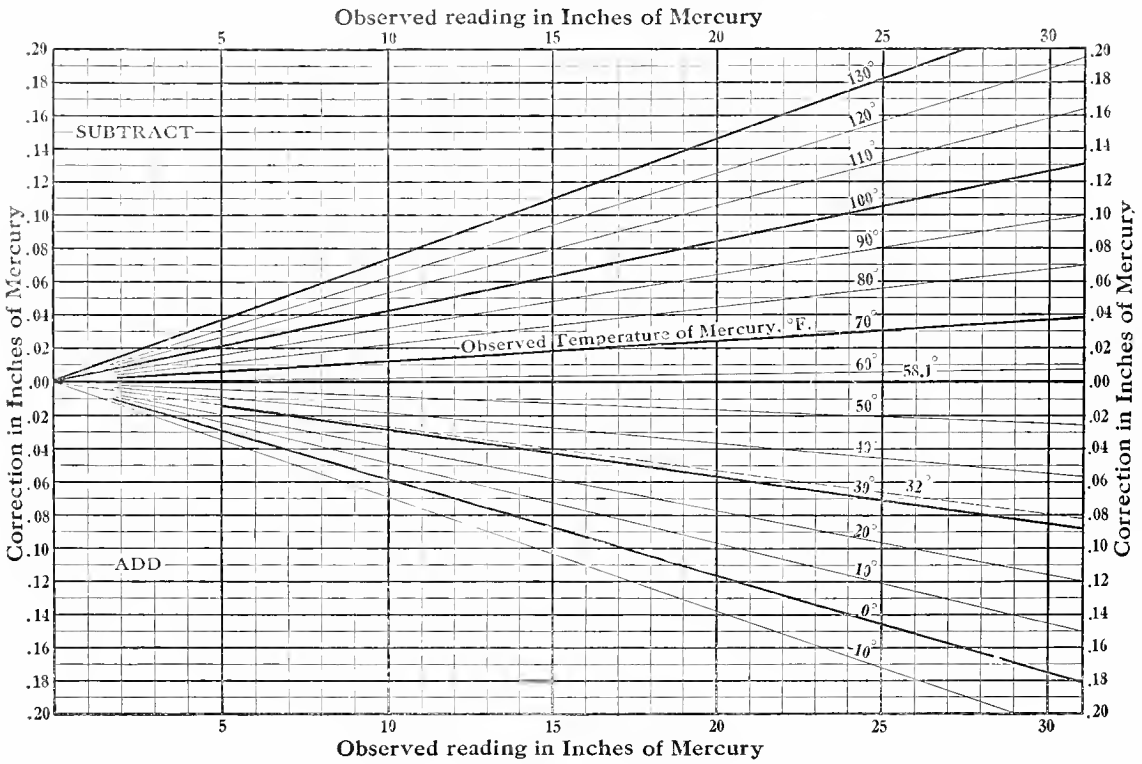


Plate 9B

Showing correction of Barometric Reading due to change in Elevation

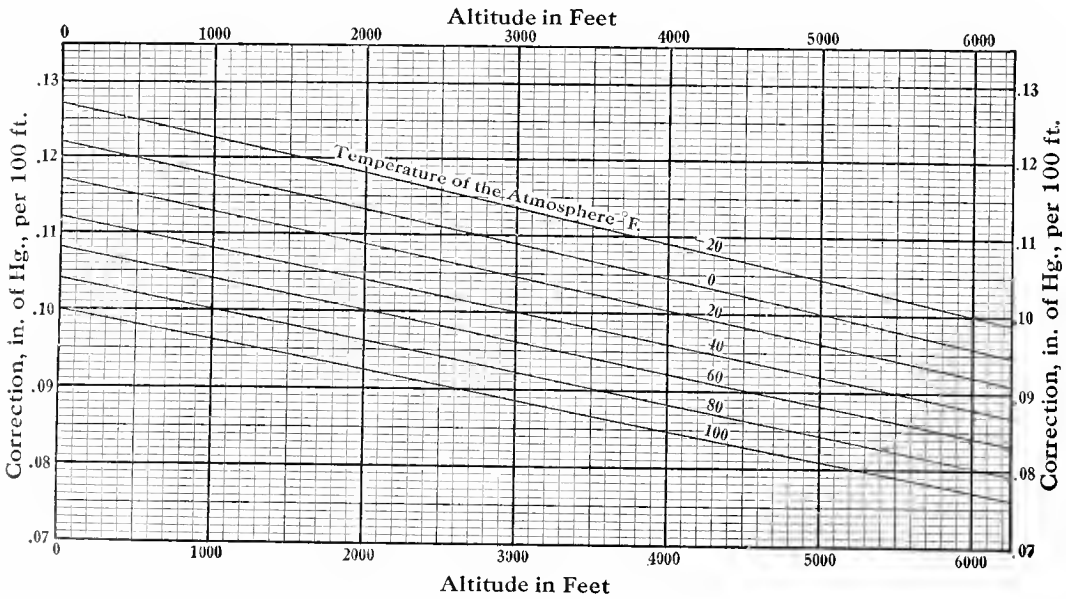


TABLE I

SHOWING CORRECTIONS TO REDUCE BAROMETRIC READINGS TO 45° LATITUDE *

For These Latitudes the Correction is to be Subtracted	Barometer Reading in Inches of Mercury									For These Latitudes the Correction is to be Added
	22	23	24	25	26	27	28	29	30	
0°	.059	.061	.064	.067	.069	.072	.074	.077	.080	90°
10°	.055	.058	.060	.063	.065	.068	.070	.073	.075	80°
20°	.045	.047	.049	.051	.053	.055	.057	.059	.061	70°
30°	.029	.031	.032	.033	.035	.036	.037	.039	.040	60°
40°	.010	.011	.011	.012	.012	.012	.013	.013	.014	50°
45°	.000	.000	.000	.000	.000	.000	.000	.000	.000	45°

* Abridged and rearranged from Table 101 of the Smithsonian Tables.

TABLE II

CORRECTION OF THE BAROMETER FOR CAPILLARITY †

Correction to be added in inches

Diameter of Tube in Inches	Height of Meniscus in Inches							
	.01	.02	.03	.04	.05	.06	.07	.08
.15	.024	.047	.069	.092	.116	....	....	....
.20	.011	.022	.033	.045	.059	.079	....	....
.25	.006	.012	.019	.028	.037	.047	.059	....
.30	.004	.008	.013	.018	.023	.029	.035	.042
.35	....	.005	.008	.012	.015	.019	.022	.027
.40	....	.004	.006	.008	.010	.012	.014	.016
.45	....	....	.003	.005	.007	.008	.010	.012
.50	....	....	.002	.004	.005	.006	.006	.007
.55	....	....	.001	.002	.003	.004	.005	.005

† From Table 103 Smithsonian Tables, modified by giving the correction only to the nearest thousandth of an inch.

TABLE III

DENSITY OF MERCURY ‡

Temperature °F.	Pounds per Cubic Inch	Temperature °F.	Pounds per Cubic Inch
0	.4928	**58.1**	**.4899**
10	.4923	60	.4898
20	.4918	70	.4893
30	.4913	80	.4888
32	**.4912**	90	.4883
40	.4907	100	.4878
50	.4903	110	.4873

‡ See page 22.

TABLE IV

JET VELOCITY IN FEET PER SECOND FROM AN IDEAL NOZZLE FOR EACH B.T.U. UP TO 599

Available Energy B. t. u. per lb.	0	1	2	3	4	5	6	7	8	9
0	0	224	316	387	447	500	548	592	633	671
10	707	742	775	806	837	866	895	922	949	975
20	1001	1026	1050	1073	1097	1120	1141	1163	1184	1205
30	1226	1246	1266	1285	1304	1323	1342	1361	1379	1397
40	1415	1433	1450	1467	1484	1501	1517	1533	1550	1566
50	1582	1598	1613	1628	1643	1658	1673	1688	1703	1718
60	1732	1747	1761	1775	1789	1803	1817	1831	1844	1858
70	1872	1885	1898	1911	1924	1937	1950	1963	1976	1988
80	2000	2013	2026	2038	2050	2062	2074	2086	2098	2110
90	2122	2134	2146	2158	2169	2180	2191	2202	2214	2226
100	2237	2248	2259	2270	2281	2292	2303	2314	2325	2336
110	2346	2356	2367	2378	2389	2399	2409	2419	2430	2440
120	2450	2460	2470	2480	2490	2500	2511	2521	2531	2540
130	2550	2560	2570	2580	2590	2600	2609	2619	2628	2637
140	2647	2657	2666	2675	2684	2694	2703	2712	2721	2730
150	2740	2749	2758	2767	2776	2785	2794	2803	2812	2821
160	2830	2839	2848	2857	2866	2874	2882	2891	2900	2908
170	2917	2925	2934	2942	2951	2960	2968	2976	2984	2993
180	3001	3010	3018	3026	3034	3042	3050	3059	3067	3075
190	3083	3091	3100	3108	3116	3124	3132	3140	3148	3156
200	3164	3172	3180	3188	3196	3204	3211	3219	3227	3234
210	3241	3249	3257	3265	3273	3280	3288	3296	3303	3310
220	3318	3325	3332	3340	3348	3355	3363	3370	3377	3384
230	3392	3400	3407	3414	3422	3430	3437	3444	3451	3458
240	3465	3473	3480	3487	3494	3501	3508	3516	3523	3530
250	3537	3544	3551	3558	3565	3572	3579	3586	3593	3600
260	3607	3614	3620	3627	3634	3641	3648	3655	3662	3669
270	3676	3683	3689	3696	3703	3710	3717	3723	3730	3737
280	3743	3750	3757	3763	3770	3777	3783	3790	3796	3803
290	3810	3817	3823	3829	3835	3842	3849	3855	3861	3868

TABLE IV

JET VELOCITY IN FEET PER SECOND FROM AN IDEAL NOZZLE FOR EACH B.T.U. UP TO 599

Available Energy B. t. u. per lb.	0	1	2	3	4	5	6	7	8	9
300	3874	3881	3888	3894	3900	3907	3913	3920	3926	3932
310	3939	3946	3952	3958	3964	3970	3976	3982	3989	3995
320	4002	4008	4014	4020	4027	4033	4039	4045	4051	4058
330	4063	4070	4076	4082	4088	4094	4100	4107	4113	4119
340	4125	4131	4137	4143	4149	4155	4161	4167	4173	4179
350	4185	4191	4197	4203	4209	4215	4221	4227	4233	4239
360	4245	4251	4257	4263	4268	4274	4280	4286	4291	4297
370	4302	4308	4314	4320	4326	4332	4338	4344	4350	4356
380	4361	4367	4372	4378	4383	4389	4395	4401	4407	4413
390	4418	4424	4430	4435	4440	4446	4451	4457	4462	4468
400	4473	4479	4485	4490	4496	4502	4508	4513	4519	4524
410	4530	4536	4541	4547	4552	4558	4563	4569	4574	4580
420	4585	4590	4596	4601	4607	4612	4617	4623	4628	4634
430	4639	4644	4650	4655	4661	4666	4671	4677	4682	4688
440	4693	4698	4703	4709	4714	4719	4724	4729	4735	4740
450	4745	4750	4755	4761	4766	4771	4776	4781	4787	4792
460	4797	4802	4808	4813	4818	4823	4828	4833	4839	4844
470	4849	4854	4859	4865	4871	4875	4880	4885	4891	4896
480	4901	4906	4911	4917	4922	4927	4932	4937	4942	4947
490	4952	4957	4962	4967	4972	4977	4982	4987	4992	4997
500	5002	5007	5012	5017	5022	5027	5032	5037	5042	5047
510	5052	5057	5062	5067	5072	5077	5082	5087	5091	5096
520	5101	5106	5111	5116	5121	5126	5131	5136	5140	5145
530	5150	5155	5160	5164	5169	5174	5179	5184	5188	5193
540	5198	5203	5208	5212	5217	5222	5227	5232	5236	5241
550	5246	5251	5256	5260	5265	5270	5275	5280	5284	5289
560	5294	5299	5303	5308	5312	5317	5322	5327	5331	5336
570	5341	5346	5350	5355	5359	5364	5369	5373	5378	5382
580	5387	5392	5397	5401	5406	5411	5416	5420	5425	5429
590	5434	5439	5443	5448	5452	5457	5461	5466	5470	5475

TABLE V

JET VELOCITY IN FEET PER SECOND FROM AN IDEAL NOZZLE FOR EACH TENTH OF A B.T.U. UP TO 80

Available Energy B. t. u. per lb.	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9	Available Energy B. t. u. per lb.
0	0	71	100	122	141	158	173	187	200	212	0
1	224	235	245	255	265	274	283	292	300	308	1
2	316	324	332	339	347	354	360	367	374	381	2
3	387	394	400	406	412	418	424	430	436	442	3
4	447	453	458	463	469	474	480	486	491	496	4
5	500	505	510	515	520	525	530	534	539	544	5
6	548	553	557	562	567	572	576	580	584	588	6
7	592	596	600	604	608	613	617	621	625	629	7
8	633	637	641	645	649	653	656	659	663	667	8
9	671	675	678	682	685	689	692	696	700	704	9
10	707	710	714	718	721	725	728	732	735	739	10
11	742	746	749	753	757	760	763	766	769	772	11
12	775	779	782	785	788	791	794	797	800	803	12
13	806	810	813	816	819	821	824	827	830	833	13
14	836	839	842	845	848	851	854	857	860	863	14
15	866	869	872	875	878	881	884	887	890	893	15
16	895	898	901	904	907	909	912	915	918	921	16
17	923	925	928	931	934	936	939	942	945	947	17
18	949	952	955	957	960	962	965	967	970	972	18
19	975	977	980	982	985	987	990	993	995	998	19
20	1001	1003	1006	1008	1011	1013	1015	1018	1020	1023	20
21	1026	1028	1031	1033	1036	1038	1041	1043	1046	1048	21
22	1050	1053	1055	1057	1060	1062	1064	1067	1070	1072	22
23	1074	1076	1079	1081	1083	1085	1088	1090	1093	1095	23
24	1097	1099	1101	1104	1106	1108	1111	1113	1115	1118	24
25	1120	1122	1124	1126	1128	1130	1133	1135	1137	1139	25
26	1141	1143	1145	1148	1150	1152	1154	1156	1159	1161	26
27	1163	1165	1167	1169	1171	1174	1176	1178	1180	1182	27
28	1184	1186	1188	1190	1192	1195	1197	1199	1201	1203	28
29	1205	1207	1209	1211	1213	1216	1218	1220	1222	1224	29
30	1226	1228	1230	1232	1234	1236	1238	1240	1242	1244	30
31	1246	1248	1250	1252	1254	1256	1258	1260	1262	1264	31
32	1266	1268	1270	1272	1274	1276	1278	1280	1281	1283	32
33	1285	1287	1289	1290	1292	1294	1296	1298	1300	1302	33
34	1304	1306	1308	1310	1312	1314	1316	1317	1319	1321	34
35	1323	1325	1327	1329	1331	1333	1334	1336	1338	1340	35
36	1342	1344	1346	1348	1350	1352	1353	1355	1357	1359	36
37	1361	1363	1365	1366	1368	1370	1372	1374	1375	1377	37
38	1379	1381	1383	1384	1386	1388	1390	1392	1393	1395	38
39	1397	1399	1401	1402	1404	1406	1408	1410	1411	1413	39
40	1415	1417	1419	1420	1422	1424	1426	1428	1429	1431	40

TABLE V

JET VELOCITY IN FEET PER SECOND FROM AN IDEAL NOZZLE FOR EACH TENTH OF A B.T.U. UP TO 80

Available Energy B. t. u. per lb.	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9	Available Energy B. t. u. per lb.
41	1433	1435	1436	1438	1440	1441	1443	1445	1446	1448	41
42	1450	1452	1453	1455	1457	1458	1460	1462	1463	1465	42
43	1467	1469	1470	1472	1474	1475	1477	1479	1480	1482	43
44	1484	1486	1487	1489	1491	1492	1494	1496	1497	1499	44
45	1501	1503	1504	1506	1507	1509	1510	1512	1513	1515	45
46	1517	1519	1520	1522	1523	1525	1526	1528	1529	1531	46
47	1533	1535	1536	1538	1540	1541	1543	1545	1546	1548	47
48	1550	1552	1553	1555	1556	1558	1559	1561	1562	1564	48
49	1566	1568	1569	1571	1572	1574	1575	1577	1578	1580	49
50	1582	1584	1585	1587	1588	1590	1591	1593	1594	1596	50
51	1598	1600	1601	1603	1604	1606	1607	1609	1610	1612	51
52	1613	1615	1616	1618	1619	1621	1622	1624	1625	1627	52
53	1628	1630	1631	1633	1634	1636	1637	1639	1640	1642	53
54	1643	1645	1646	1648	1649	1651	1652	1654	1655	1657	54
55	1658	1660	1661	1663	1664	1666	1667	1669	1670	1672	55
56	1673	1675	1676	1678	1679	1681	1682	1684	1685	1687	56
57	1688	1690	1691	1693	1694	1696	1697	1699	1700	1702	57
58	1703	1705	1706	1708	1709	1711	1712	1714	1715	1717	58
59	1718	1720	1721	1723	1724	1726	1727	1729	1730	1731	59
60	1732	1734	1735	1737	1738	1740	1741	1743	1744	1746	60
61	1747	1749	1750	1752	1753	1755	1756	1758	1759	1760	61
62	1761	1763	1764	1766	1767	1769	1770	1772	1773	1774	62
63	1775	1777	1778	1780	1781	1783	1784	1786	1787	1788	63
64	1789	1791	1792	1794	1795	1797	1798	1800	1801	1802	64
65	1803	1805	1806	1808	1809	1811	1812	1814	1815	1816	65
66	1817	1819	1820	1822	1823	1825	1826	1828	1829	1830	66
67	1831	1833	1834	1836	1837	1838	1839	1841	1842	1843	67
68	1844	1846	1847	1849	1850	1852	1853	1855	1856	1857	68
69	1858	1860	1861	1863	1864	1866	1867	1869	1870	1871	69
70	1872	1874	1875	1876	1878	1879	1880	1882	1883	1884	70
71	1885	1887	1888	1889	1891	1892	1893	1895	1896	1897	71
72	1898	1900	1901	1902	1904	1905	1906	1908	1909	1910	72
73	1911	1913	1914	1915	1917	1918	1919	1921	1922	1923	73
74	1924	1926	1927	1928	1930	1931	1932	1934	1935	1936	74
75	1937	1939	1940	1941	1943	1944	1945	1947	1948	1949	75
76	1950	1952	1953	1954	1956	1957	1958	1960	1961	1962	76
77	1963	1965	1966	1967	1969	1970	1971	1973	1974	1975	77
78	1976	1977	1978	1979	1981	1982	1983	1984	1985	1987	78
79	1988	1989	1990	1991	1993	1994	1995	1996	1997	1999	79

TABLE VI

SQUARES OF NUMBERS, FROM 200 TO 2000, EXPRESSED IN MILLIONS, BY THE NEAREST FOUR FIGURES

N	0.	1.	2.	3.	4.	5.	6.	7.	8.	9.	N
200	.0400	.0404	.0408	.0412	.0416	.0420	.0424	.0428	.0432	.0437	200
210	.0441	.0445	.0449	.0454	.0458	.0462	.0466	.0471	.0475	.0480	210
220	.0484	.0488	.0493	.0497	.0502	.0506	.0511	.0515	.0520	.0524	220
230	.0529	.0534	.0538	.0543	.0548	.0552	.0557	.0562	.0566	.0571	230
240	.0576	.0581	.0586	.0590	.0595	.0600	.0605	.0610	.0615	.0620	240
250	.0625	.0630	.0635	.0640	.0645	.0650	.0655	.0660	.0666	.0671	250
260	.0676	.0681	.0686	.0692	.0697	.0702	.0708	.0713	.0718	.0724	260
270	.0729	.0734	.0740	.0745	.0751	.0756	.0762	.0767	.0773	.0778	270
280	.0784	.0790	.0795	.0801	.0807	.0812	.0818	.0824	.0829	.0835	280
290	.0841	.0847	.0853	.0858	.0864	.0870	.0876	.0882	.0888	.0894	290
300	.0900	.0906	.0912	.0918	.0924	.0930	.0936	.0942	.0949	.0955	300
310	.0961	.0967	.0973	.0980	.0986	.0992	.0999	.1005	.1011	.1018	310
320	.1024	.1030	.1037	.1043	.1050	.1056	.1063	.1069	.1076	.1082	320
330	.1089	.1096	.1102	.1109	.1116	.1122	.1129	.1136	.1142	.1149	330
340	.1156	.1163	.1170	.1176	.1183	.1190	.1197	.1204	.1211	.1218	340
350	.1225	.1232	.1239	.1246	.1253	.1260	.1267	.1274	.1282	.1289	350
360	.1296	.1303	.1310	.1318	.1325	.1332	.1340	.1347	.1354	.1362	360
370	.1369	.1376	.1384	.1391	.1399	.1406	.1414	.1421	.1429	.1436	370
380	.1444	.1452	.1459	.1467	.1475	.1482	.1490	.1498	.1505	.1513	380
390	.1521	.1529	.1537	.1544	.1552	.1560	.1568	.1576	.1584	.1592	390
400	.1600	.1608	.1616	.1624	.1632	.1640	.1648	.1656	.1665	.1673	400
410	.1681	.1689	.1697	.1706	.1714	.1722	.1731	.1739	.1747	.1756	410
420	.1764	.1772	.1781	.1789	.1798	.1806	.1815	.1823	.1832	.1840	420
430	.1849	.1858	.1866	.1875	.1884	.1892	.1901	.1910	.1918	.1927	430
440	.1936	.1945	.1953	.1962	.1971	.1980	.1989	.1998	.2007	.2016	440
450	.2025	.2034	.2043	.2052	.2061	.2070	.2079	.2088	.2098	.2107	450
460	.2116	.2125	.2134	.2144	.2153	.2162	.2172	.2181	.2190	.2200	460
470	.2209	.2218	.2228	.2237	.2247	.2256	.2266	.2275	.2285	.2294	470
480	.2304	.2314	.2323	.2333	.2343	.2352	.2362	.2372	.2381	.2391	480
490	.2401	.2411	.2421	.2430	.2440	.2450	.2460	.2470	.2480	.2490	490
500	.2500	.2510	.2520	.2530	.2540	.2550	.2560	.2570	.2581	.2591	500
510	.2601	.2611	.2621	.2632	.2642	.2652	.2663	.2673	.2683	.2694	510
520	.2704	.2714	.2725	.2735	.2746	.2756	.2767	.2777	.2788	.2798	520
530	.2809	.2820	.2830	.2841	.2852	.2862	.2873	.2884	.2894	.2905	530
540	.2916	.2927	.2938	.2949	.2959	.2970	.2981	.2992	.3003	.3014	540
550	.3025	.3036	.3047	.3058	.3069	.3080	.3091	.3102	.3114	.3125	550
560	.3136	.3147	.3158	.3170	.3181	.3192	.3204	.3215	.3226	.3238	560
570	.3249	.3260	.3272	.3283	.3295	.3306	.3318	.3329	.3341	.3352	570
580	.3364	.3376	.3387	.3399	.3411	.3422	.3434	.3446	.3457	.3469	580
590	.3481	.3493	.3505	.3516	.3528	.3540	.3552	.3564	.3576	.3588	590
600	.3600	.3612	.3624	.3636	.3648	.3660	.3672	.3684	.3697	.3709	600
610	.3721	.3733	.3745	.3758	.3770	.3782	.3795	.3807	.3819	.3832	610
620	.3844	.3856	.3869	.3881	.3894	.3906	.3919	.3931	.3944	.3956	620
630	.3969	.3982	.3994	.4007	.4020	.4032	.4045	.4058	.4070	.4083	630
640	.4096	.4109	.4122	.4134	.4147	.4160	.4173	.4186	.4199	.4212	640

TABLE VI

SQUARES OF NUMBERS, FROM 200 TO 2000, EXPRESSED IN MILLIONS, BY THE NEAREST FOUR FIGURES

N	0.	1.	2.	3.	4.	5.	6.	7.	8.	9.	N
650	.4225	.4238	.4251	.4264	.4277	.4290	.4303	.4316	.4330	.4343	650
660	.4356	.4369	.4382	.4396	.4409	.4422	.4436	.4449	.4462	.4476	660
670	.4489	.4502	.4516	.4529	.4543	.4556	.4570	.4583	.4597	.4610	670
680	.4624	.4638	.4651	.4665	.4679	.4692	.4706	.4720	.4733	.4747	680
690	.4761	.4775	.4789	.4802	.4816	.4830	.4844	.4858	.4872	.4886	690
700	.4900	.4914	.4928	.4942	.4956	.4970	.4984	.4998	.5013	.5027	700
710	.5041	.5055	.5069	.5084	.5098	.5112	.5127	.5141	.5155	.5170	710
720	.5184	.5198	.5213	.5228	.5242	.5256	.5271	.5285	.5300	.5314	720
730	.5329	.5344	.5358	.5373	.5388	.5402	.5417	.5432	.5446	.5461	730
740	.5476	.5491	.5506	.5520	.5535	.5550	.5565	.5580	.5595	.5610	740
750	.5625	.5640	.5655	.5670	.5685	.5700	.5715	.5730	.5746	.5761	750
760	.5776	.5791	.5806	.5822	.5837	.5852	.5868	.5883	.5898	.5914	760
770	.5929	.5944	.5960	.5975	.5991	.6006	.6022	.6037	.6053	.6068	770
780	.6084	.6100	.6115	.6131	.6147	.6162	.6178	.6194	.6209	.6225	780
790	.6241	.6257	.6273	.6288	.6304	.6320	.6336	.6352	.6368	.6384	790
800	.6400	.6416	.6432	.6448	.6464	.6480	.6496	.6512	.6529	.6545	800
810	.6561	.6577	.6593	.6610	.6626	.6642	.6659	.6675	.6691	.6708	810
820	.6724	.6740	.6757	.6773	.6790	.6806	.6823	.6839	.6856	.6872	820
830	.6889	.6906	.6922	.6939	.6956	.6972	.6989	.7006	.7022	.7039	830
840	.7056	.7073	.7090	.7106	.7123	.7140	.7157	.7174	.7191	.7208	840
850	.7225	.7242	.7259	.7276	.7293	.7310	.7327	7344	.7362	.7379	850
860	.7396	.7413	.7430	.7448	.7465	.7482	.7500	.7517	.7534	.7552	860
870	.7569	7586	.7604	.7621	.7639	.7656	.7674	.7691	.7709	.7726	870
880	.7744	.7762	.7779	.7797	.7815	.7832	.7850	.7868	.7885	.7903	880
890	.7921	.7939	.7957	.7974	.7992	.8010	.8028	.8046	.8064	.8082	890
900	.8100	.8118	.8136	.8154	.8172	.8190	.8208	.8226	.8245	.8263	900
910	.8281	.8299	.8317	.8336	.8354	.8372	.8391	.8409	.8427	.8446	910
920	.8464	.8482	.8501	.8519	.8538	.8556	.8575	.8593	.8612	.8630	920
930	.8649	.8668	.8686	.8705	.8724	.8742	.8761	.8780	.8798	.8817	930
940	.8836	.8855	.8874	.8892	.8911	.8930	.8949	.8968	.8987	.9006	940
950	.9025	.9044	.9063	.9082	.9101	.9120	.9139	.9158	.9178	.9197	950
960	.9216	.9235	.9254	.9274	.9293	.9312	.9332	.9351	.9370	.9390	960
970	.9409	.9428	.9448	.9467	.9487	.9506	.9526	.9545	.9565	.9584	970
980	.9604	.9624	.9643	.9663	.9683	.9702	.9722	.9742	.9761	.9781	980
990	.9801	.9821	.9841	.9860	.9880	.9900	.9920	.9940	.9960	.9980	990
1000	1.000	1.002	1.004	1.006	1.008	1.010	1.012	1.014	1.016	1.018	1000
1010	1.020	1.022	1.024	1.026	1.028	1.030	1.032	1.034	1.036	1.038	1010
1020	1.040	1.042	1.044	1.047	1.049	1.051	1.053	1.055	1.057	1.059	1020
1030	1.061	1.063	1.065	1.067	1.069	1.071	1.073	1.075	1.077	1.080	1030
1040	1.082	1.084	1.086	1.088	1.090	1.092	1.094	1.096	1.098	1.100	1040
1050	1.102	1.105	1.107	1.109	1.111	1.113	1.115	1.117	1.119	1.121	1050
1060	1.124	1.126	1.128	1.130	1.132	1.134	1.136	1.138	1.141	1.143	1060
1070	1.145	1.147	1.149	1.151	1.153	1.156	1.158	1.160	1.162	1.164	1070
1080	1.166	1.169	1.171	1.173	1.175	1.177	1.179	1.182	1.184	1.186	1080
1090	1.188	1.190	1.192	1.195	1.197	1.199	1.201	1.203	1.206	1.208	1090

TABLE VI

SQUARES OF NUMBERS, FROM 200 TO 2000, EXPRESSED IN MILLIONS, BY THE NEAREST FOUR FIGURES

N	0.	1.	2.	3.	4.	5.	6.	7.	8.	9.	N
1100	1.210	1.212	1.214	1.217	1.219	1.221	1.223	1.225	1.228	1.230	1100
1110	1.232	1.234	1.237	1.239	1.241	1.243	1.245	1.248	1.250	1.252	1110
1120	1.254	1.257	1.259	1.261	1.263	1.266	1.268	1.270	1.272	1.275	1120
1130	1.277	1.279	1.281	1.284	1.286	1.288	1.290	1.293	1.295	1.297	1130
1140	1.300	1.302	1.304	1.306	1.309	1.311	1.313	1.316	1.318	1.320	1140
1150	1.322	1.325	1.327	1.329	1.332	1.334	1.336	1.339	1.341	1.343	1150
1160	1.346	1.348	1.350	1.353	1.355	1.357	1.360	1.362	1.364	1.367	1160
1170	1.369	1.371	1.374	1.376	1.378	1.381	1.383	1.385	1.388	1.390	1170
1180	1.392	1.395	1.397	1.399	1.402	1.404	1.407	1.409	1.411	1.414	1180
1190	1.416	1.418	1.421	1.423	1.426	1.428	1.430	1.433	1.435	1.438	1190
1200	1.440	1.442	1.445	1.447	1.450	1.452	1.454	1.457	1.459	1.462	1200
1210	1.464	1.467	1.469	1.471	1.474	1.476	1.479	1.481	1.484	1.486	1210
1220	1.488	1.491	1.493	1.496	1.498	1.501	1.503	1.506	1.508	1.510	1220
1230	1.513	1.515	1.518	1.520	1.523	1.525	1.528	1.530	1.533	1.535	1230
1240	1.538	1.540	1.543	1.545	1.548	1.550	1.553	1.555	1.558	1.560	1240
1250	1.563	1.565	1.568	1.570	1.573	1.575	1.578	1.580	1.583	1.585	1250
1260	1.588	1.590	1.593	1.595	1.598	1.600	1.603	1.605	1.608	1.610	1260
1270	1.613	1.615	1.618	1.621	1.623	1.626	1.628	1.631	1.633	1.636	1270
1280	1.638	1.641	1.644	1.646	1.649	1.651	1.654	1.656	1.659	1.662	1280
1290	1.664	1.667	1.669	1.672	1.674	1.677	1.680	1.682	1.685	1.687	1290
1300	1.690	1.693	1.695	1.698	1.700	1.703	1.706	1.708	1.711	1.713	1300
1310	1.716	1.719	1.721	1.724	1.727	1.729	1.732	1.734	1.737	1.740	1310
1320	1.742	1.745	1.748	1.750	1.753	1.756	1.758	1.761	1.764	1.766	1320
1330	1.769	1.772	1.774	1.777	1.780	1.782	1.785	1.788	1.790	1.793	1330
1340	1.796	1.798	1.801	1.804	1.806	1.809	1.812	1.814	1.817	1.820	1340
1350	1.822	1.825	1.828	1.831	1.833	1.836	1.839	1.841	1.844	1.847	1350
1360	1.850	1.852	1.855	1.858	1.860	1.863	1.866	1.869	1.871	1.874	1360
1370	1.877	1.880	1.882	1.885	1.888	1.891	1.893	1.896	1.899	1.902	1370
1380	1.904	1.907	1.910	1.913	1.915	1.918	1.921	1.924	1.927	1.929	1380
1390	1.932	1.935	1.938	1.940	1.943	1.946	1.949	1.952	1.954	1.957	1390
1400	1.960	1.963	1.966	1.968	1.971	1.974	1.977	1.980	1.982	1.985	1400
1410	1.988	1.991	1.994	1.997	1.999	2.002	2.005	2.008	2.011	2.014	1410
1420	2.016	2.019	2.022	2.025	2.028	2.031	2.033	2.036	2.039	2.042	1420
1430	2.045	2.048	2.051	2.053	2.056	2.059	2.062	2.065	2.068	2.071	1430
1440	2.074	2.076	2.079	2.082	2.085	2.088	2.091	2.094	2.097	2.100	1440
1450	2.102	2.105	2.108	2.111	2.114	2.117	2.120	2.123	2.126	2.129	1450
1460	2.132	2.135	2.137	2.140	2.143	2.146	2.149	2.152	2.155	2.158	1460
1470	2.161	2.164	2.167	2.170	2.173	2.176	2.179	2.182	2.184	2.187	1470
1480	2.190	2.193	2.196	2.199	2.202	2.205	2.208	2.211	2.214	2.217	1480
1490	2.220	2.223	2.226	2.229	2.232	2.235	2.238	2.241	2.244	2.247	1490
1500	2.250	2.253	2.256	2.259	2.262	2.265	2.268	2.271	2.274	2.277	1500
1510	2.280	2.283	2.286	2.289	2.292	2.295	2.298	2.301	2.304	2.307	1510
1520	2.310	2.313	2.316	2.320	2.323	2.326	2.329	2.332	2.335	2.338	1520
1530	2.341	2.344	2.347	2.350	2.353	2.356	2.359	2.362	2.365	2.369	1530
1540	2.372	2.375	2.378	2.381	2.384	2.387	2.390	2.393	2.396	2.399	1540

TABLE VI

SQUARES OF NUMBERS, FROM 200 TO 2000, EXPRESSED IN MILLIONS, BY THE NEAREST FOUR FIGURES

N	0.	1.	2.	3.	4.	5.	6.	7.	8.	9.	N
1550	2.402	2.406	2.409	2.412	2.415	2.418	2.421	2.424	2.427	2.430	1550
1560	2.434	2.437	2.440	2.443	2.446	2.449	2.452	2.455	2.459	2.462	1560
1570	2.465	2.468	2.471	2.474	2.477	2.481	2.484	2.487	2.490	2.493	1570
1580	2.496	2.500	2.503	2.506	2.509	2.512	2.515	2.519	2.522	2.525	1580
1590	2.528	2.531	2.534	2.538	2.541	2.544	2.547	2.550	2.554	2.557	1590
1600	2.560	2.563	2.566	2.570	2.573	2.576	2.579	2.582	2.586	2.589	1600
1610	2.592	2.595	2.599	2.602	2.605	2.608	2.611	2.615	2.618	2.621	1610
1620	2.624	2.628	2.631	2.634	2.637	2.641	2.644	2.647	2.650	2.654	1620
1630	2.657	2.660	2.663	2.667	2.670	2.673	2.676	2.680	2.683	2.686	1630
1640	2.690	2.693	2.696	2.699	2.703	2.706	2.709	2.713	2.716	2.719	1640
1650	2.722	2.726	2.729	2.732	2.736	2.739	2.742	2.746	2.749	2.752	1650
1660	2.756	2.759	2.762	2.766	2.769	2.772	2.776	2.779	2.782	2.786	1660
1670	2.789	2.792	2.796	2.799	2.802	2.806	2.809	2.812	2.816	2.819	1670
1680	2.822	2.826	2.829	2.832	2.836	2.839	2.843	2.846	2.849	2.853	1680
1690	2.856	2.859	2.863	2.866	2.870	2.873	2.876	2.880	2.883	2.887	1690
1700	2.890	2.893	2.897	2.900	2.904	2.907	2.910	2.914	2.917	2.921	1700
1710	2.924	2.928	2.931	2.934	2.938	2.941	2.945	2.948	2.952	2.955	1710
1720	2.958	2.962	2.965	2.969	2.972	2.976	2.979	2.983	2.986	2.989	1720
1730	2.993	2.996	3.000	3.003	3.007	3.010	3.014	3.017	3.021	3.024	1730
1740	3.028	3.031	3.035	3.038	3.042	3.045	3.049	3.052	3.056	3.059	1740
1750	3.062	3.066	3.070	3.073	3.077	3.080	3.084	3.087	3.091	3.094	1750
1760	3.098	3.101	3.105	3.108	3.112	3.115	3.119	3.122	3.126	3.129	1760
1770	3.133	3.136	3.140	3.144	3.147	3.151	3.154	3.158	3.161	3.165	1770
1780	3.168	3.172	3.176	3.179	3.183	3.186	3.190	3.193	3.197	3.201	1780
1790	3.204	3.208	3.211	3.215	3.218	3.222	3.226	3.229	3.233	3.236	1790
1800	3.240	3.244	3.247	3.251	3.254	3.258	3.262	3.265	3.269	3.272	1800
1810	3.276	3.280	3.283	3.287	3.291	3.294	3.298	3.301	3.305	3.309	1810
1820	3.312	3.316	3.320	3.323	3.327	3.331	3.334	3.338	3.342	3.345	1820
1830	3.349	3.353	3.356	3.360	3.364	3.367	3.371	3.375	3.378	3.382	1830
1840	3.386	3.389	3.393	3.397	3.400	3.404	3.408	3.411	3.415	3.419	1840
1850	3.422	3.426	3.430	3.434	3.437	3.441	3.445	3.448	3.452	3.456	1850
1860	3.460	3.463	3.467	3.471	3.474	3.478	3.482	3.486	3.489	3.493	1860
1870	3.497	3.501	3.504	3.508	3.512	3.516	3.519	3.523	3.527	3.531	1870
1880	3.534	3.538	3.542	3.546	3.549	3.553	3.557	3.561	3.565	3.568	1880
1890	3.572	3.576	3.580	3.583	3.587	3.591	3.595	3.599	3.602	3.606	1890
1900	3.610	3.614	3.618	3.621	3.625	3.629	3.633	3.637	3.640	3.644	1900
1910	3.648	3.652	3.656	3.660	3.663	3.667	3.671	3.675	3.679	3.683	1910
1920	3.686	3.690	3.694	3.698	3.702	3.706	3.709	3.713	3.717	3.721	1920
1930	3.725	3.729	3.733	3.736	3.740	3.744	3.748	3.752	3.756	3.760	1930
1940	3.764	3.767	3.771	3.775	3.779	3.783	3.787	3.791	3.795	3.799	1940
1950	3.802	3.806	3.810	3.814	3.818	3.822	3.826	3.830	3.834	3.838	1950
1960	3.842	3.846	3.849	3.853	3.857	3.861	3.865	3.869	3.873	3.877	1960
1970	3.881	3.885	3.889	3.893	3.897	3.901	3.905	3.909	3.912	3.916	1970
1980	3.920	3.924	3.928	3.932	3.936	3.940	3.944	3.948	3.952	3.956	1980
[illegible]	[illegible]	[illegible]	3.968	3.972	3.976	3.980	3.984	3.988	3.992	3.996	1990